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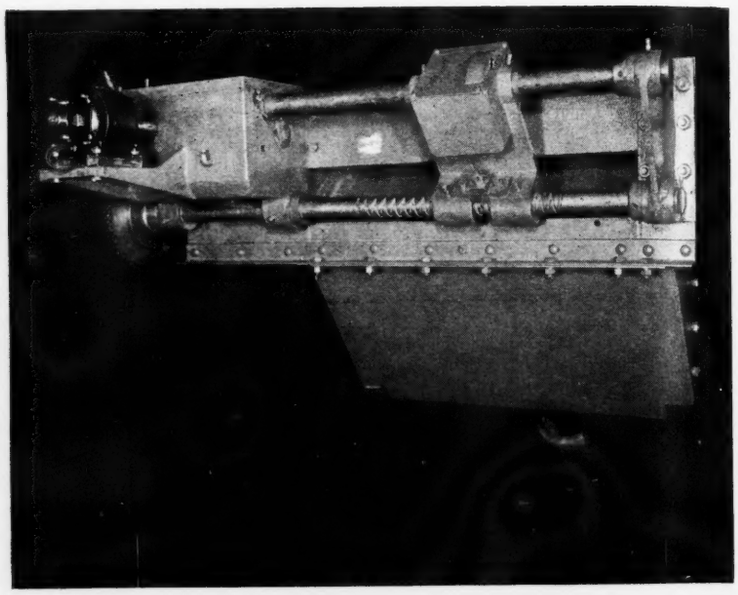

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POWER

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ELY C. HUTCHINSON, *Editor*

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Valedictory

TO THE MEMBERS of the National Association of Power Engineers, in convention assembled or staying by their plants, Greeting! I joined the association forty-six years ago and have been a member ever since.

Forty-three years ago this month I became editor of *Power*.

Both have been pleasant and profitable connections. The editorship has furnished to me many pleasant opportunities of travel and contact, and membership in this and other societies has brought me valued friendships, the knowledge of what the readers of *Power* wanted and of where to get it for them.

The management of *Power* realized that the time was approaching when the leadership of and the responsibility for the paper must be transferred to those who would be active and effective when I would be no longer available; that upon my passing the paper must not be left without a leader who had been tried out and won his spurs.

And then, by forty-odd years of service, I had earned the right to play. For several years I have been relieved of responsibility for details and of regular attendance at the office. A short time ago I relinquished the editorial chair and title to the present capable incumbent, and am able through the consideration of the company to settle down quietly to the prospect of growing old.

As Editor Emeritus I have kept up my contributions to the foreword page. In my opinion the time has come to discontinue these too. I do this with reluctance, and temper my regret at this more complete severance of my relations with those whom I have been addressing these many years by promising myself and them that as occasions arise and thoughts present themselves I will keep the contact alive and the communication open.

With a keen appreciation of the indulgence shown me and of the kindly comments which these weekly observations have elicited, I retire to the wings to look on calmly at the passing show, awaiting no importunate cue but feeling free to interject a comment when the spirit moves.

F. R. Low

EDITORIAL

POWER Stands for . .

1. Making Power When It Should Be Made
2. Buying Power When It Should Be Bought
3. Cheaper Power Through Modern Equipment
4. Easier Financing of Equipment Purchases
5. Better Use of Byproduct Heat and Power
6. Operating Methods That Save Money
7. Less Waste in Transmission and Application
8. Prevention of Smoke, Within Reason

Modern Operation Offers Broad Opportunities

SOME WEEKS AGO an old-time reader wrote for advice as to whether he should encourage his son's desire to become an operating engineer. The father was an engineer of the old school who had been in charge of a small plant for many years. He had some misgivings as to the future of the industrial power plant and the opportunities an operating job offered from the standpoints of experience and remuneration. These misgivings, presumably, were based on his own experience, and, like most fathers, he desired something better for his son.

Provided that the young man was mechanically inclined, it was pointed out to the father that the operating field today offers greater opportunities to men of initiative and aptitude than ever before. It is true that larger concentrations of power and the consequent decrease in the number of smaller plants has reduced the number of operating positions. On the other hand, advances in operating practice, the introduction of higher pressures, use of modern equipment, and the extension of power services in the larger and better plants have intensified and multiplied operating problems so as to offer a far broader opportunity than the relatively simple pre-war plant, so seldom operated above nominal rating.

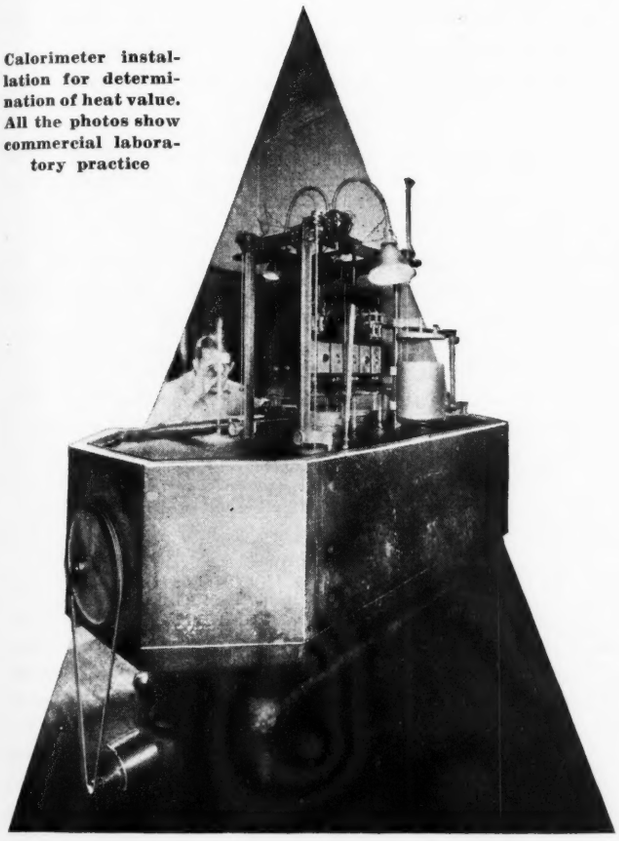
Moreover, operation today has an all-important economic aspect. This applies to the selection of fuel, the maintenance of heat balance, the proper loading of equipment, and the keeping and interpretation of records, with lower power and steam costs as the objective. The power plant is more and more regarded as a production department that must be judged not only by its excellence of service but also on its dollars-and-cents record.

Those who have the qualifications and the determination to meet these requirements need have no misgivings as to what the field offers in experience and opportunities for advancement. In this respect the power field is not unlike many other lines of endeavor. The opportunities are there and it is up to the individual to make the best of them. Mediocrity will not get one far.

This number of *Power* is dedicated to the operating engineer. If he be seasoned, but still fired with the ambition to make a better berth for himself, he will find the contents of assistance in meeting his many problems. If he be in the class with the young man about to follow in the footsteps of his father, he will find herein friendly thoughts and suggestions to smooth the way.

Modern power plant operation, because of its many ramifications, is most important. While space does not permit going into all of its details, such practical information on the handling and care of major equipment has been included as will assist operators to a better fulfillment of their responsibilities.

Saving Money BY INTELLIGENT COAL SELECTION



Calorimeter installation for determination of heat value. All the photos show commercial laboratory practice

FEW PLANTS apply scientific methods in the selection of coal. Few appreciate the substantial savings that can be made. In this field both theorists and practical operators have failed largely to understand the situation or to make practical application of existing knowledge.

Schools of engineering, on the one hand, have failed to attack the problem from all angles. Much attention has been given to heat values, and other easily determined physical characteristics of coal, but graduates have generally had no inkling of the limitations and possibilities of coal markets.

Experience Not a Safe Guide in Coal Buying

Practical operating men, often equally familiar with heat values and other laboratory data on coal, have likewise been frequently misled by their own experience. After one or two failures to operate satisfactorily with low-cost coal, they have come to the conclusion that it is necessary to burn "high-quality" coal at a heavy price premium. Sometimes they are right. More often not.

It is clear that if various coals are available, all of which will burn satisfactorily and with equal efficiency, and carry the load, the one that can be delivered at the plant for the lowest cost per million heat units is the best "buy."

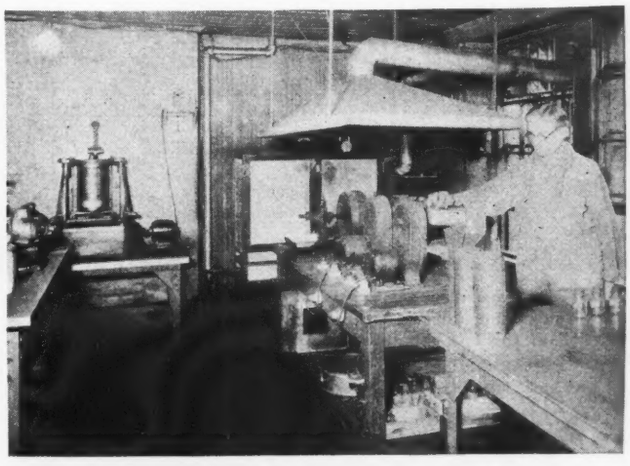
In certain industrial areas of the United States, coals of widely different characteristics and price are commercially available. In such the operator is faced with a difficult choice. Such an area is that comprising the Middle Atlantic and New England States, which are dependent upon the extensive coal fields of Pennsylvania, West Virginia and Maryland.

Selecting Coal from Eastern Fields

Approximately 60 per cent of all the bituminous coal used in the United States comes from these fields. Eliminating anthracite, these coals may be divided into three groups: *Low volatile, medium volatile,* and *high volatile.* The mine cost of each group varies materially from district to district, and from mine to mine. In addition, the relative delivered cost naturally varies with the situation of the user in respect to the source. In general, however, the low-volatile coal costs substantially more per heat unit than the high-volatile coal.

This higher heat-unit cost arises not so much from the low-volatile content itself as from certain other advantages that frequently accompany it. Of these, the chief is high fusion temperature of the ash, making possible operation without clinker trouble at high rates of combustion.

But while clinker troubles are more common with the cheaper coals, there are exceptions to the rule. These exceptions constitute a real opportunity for the Eastern plant operator who has the necessary knowledge of the coal market and its possibilities.



Coal samples must be pulverized as the first step in laboratory testing

The Eastern field has been chosen to illustrate a principle that applies everywhere. This may be stated as follows: "In any given locality the delivered prices of all available coals are never a true measure of comparative values to any given buyer."

Price Is Generally Not a True Measure of Coal Value

These prices are the net result of a great many factors, among which are the experiences and prejudices of thousands of buyers. Because of superficial resemblance, a coal which will operate satisfactorily in a given plant will be classed and priced (low) with several others that will not. If the operator can somehow distinguish this coal from its unsuitable brothers he will save money.

For example, consider a plant in any given location in the United States. The operator lists all coals reasonably available in his district, with the delivered price per ton of each. Knowing the heat value, he computes the cost of a million B.t.u. in each kind of coal, and finds an extreme variation equivalent to 50 cents to $1 per ton.

Finding that the coal he is now using is near the top price per million heat units, he looks over the list. Why not jump to the coals of the lowest B.t.u. cost? He finds that his plant was equipped by its designer with too small a grate area, or too low a pulverizer capacity, definitely limiting it to coals having a low fusion temperature of ash or a high grindability. Inspecting the cheapest coals for these characteristics, he finds that none of them will burn satisfactorily and carry the peak load in his plant.

In the middle group, likewise, he finds that most of the coals would be unsuitable for the same reason. In fact, such a large percentage would fail in his plant that the chances of finding a suitable coal in this group by random experimentation would be small. This hypothetical operator, however, possesses all the data on ash-fusion temperature, grindability, etc., and therefore soon locates a coal in this group that will meet his needs. Whereupon he makes a substantial saving in operating cost without sacrificing efficiency or ease of operation.

It is highly desirable that designers equip plants so that the operator will be free to burn any available coal, and thus select that having the lowest cost per million heat units. Where the plant is already installed it will generally be possible to go into a lower B.t.u. price range if sufficient information regarding available coals is at hand. Often the ability to go into a still lower range will warrant modernization of the combustion equipment.

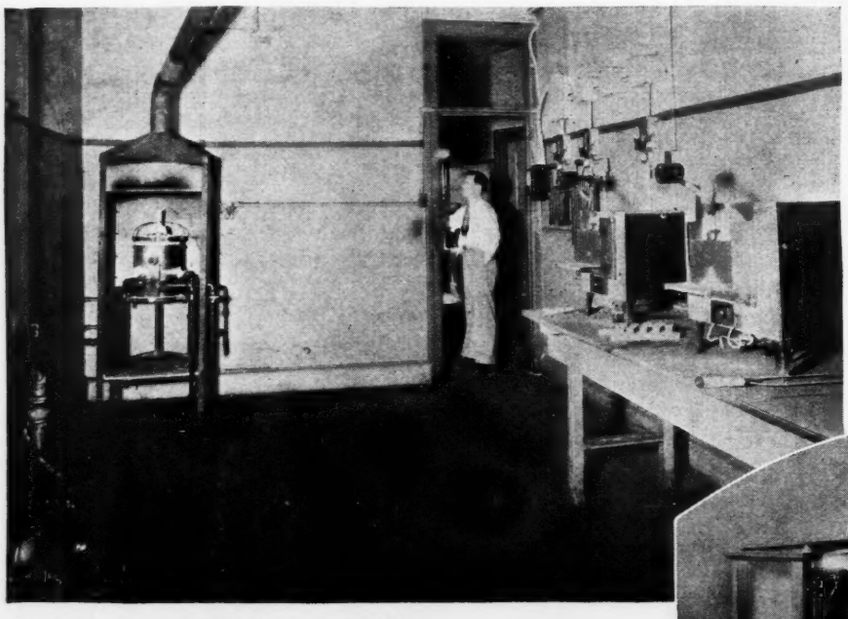
Problem Is to Find a "Poor" Coal That Is Really Good

Attention here has been directed primarily at three elements: Heat-unit cost, percentage of volatile, and tendency to clinker as measured by the fusion temperature of the ash. Other elements are size of coal, coking ability, etc. These have their effect on price, but are not generally determining factors in operation, except where draft is limited.

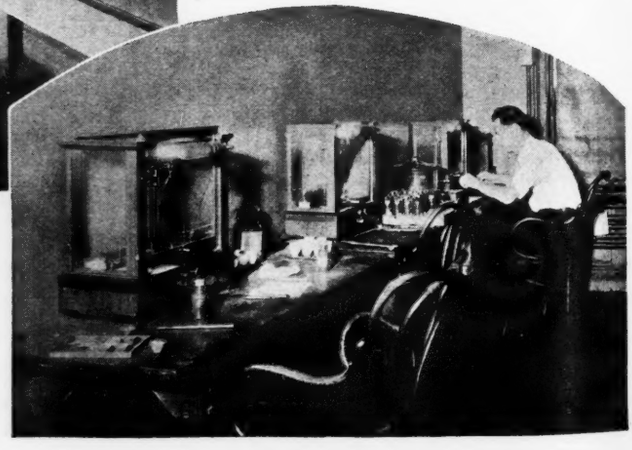
The main problem has already been pointed out. It may be restated as follows: "The primary problem in coal selection is to find a coal in a group rated poor by the run of buyers (and hence low in B.t.u. cost), but a coal that is really good as far as its performance in the given plant is concerned." Experience has shown that there are many such "B.t.u. bargains" on the market at all times.

Other Published Information

This article has stressed the most important factors in coal selection. The subject is far too large for detailed treatment in the space here available. Those interested in further details are referred to the articles, "Buying Coal for Profit," published in *Power*, April 7, 14, 21 and 29, 1931. The author of these articles, G. B. Gould, president of the Fuel Engineering Company, New York City, has also treated the subject at length in his book, "Steam Generation Steps Ahead." It is believed that Mr. Gould's writings present a fundamental and practical approach to the problem of saving money in fuel selection.



At the right are electric furnaces used for determining the amount of volatile and ash, and at the left a gas-fired furnace for determining the fusing point of the ash



A single analysis, with check, involves twenty weighings

Operation of High-Pressure Boilers

By WILLIAM F. RYAN
Mechanical Engineer
Stone & Webster Engineering Corp.

Speeding up of equipment in modern boiler plants has resulted in speeding up the operator as well. Those unable or unwilling to get into step in the faster pace should seek some other field of endeavor. Fortunately, most operators not only accept the change, but welcome it. For them new problems and temporary difficulties are only a challenge to their resourcefulness

NEARLY every article that has been published relating to operating experiences in high-pressure plants states that no difficulties have been experienced which are directly attributable to high steam pressure. The truth of this depends largely on a rather strict interpretation of the term "directly." It must also be remembered that difficulties are relative, and that a condition might be considered a serious inconvenience in one plant which would be accepted as all in the day's work in another. We all know that the successful management of a modern boiler plant requires more skill, wider knowledge, and greater attention to detail than was required in the up-to-date plant ten or fifteen years ago. Directly or indirectly, higher pressure has contributed to the increased responsibility carried by the boiler plant operator today.

The public utilities and the large industries with metallurgists, chemists, and other technical experts on their staffs, have had little difficulty in coping with the new problems of operation. Now that high pressure is common, even in smaller industrial plants, trouble has been experienced, sometimes through faulty design, but more often because the operators have not realized that there were new conditions to be dealt with.

Higher rates of combustion, and higher rates of heat transfer are the principal causes of the changed technique of boiler operation. However, the use of higher steam pressures was undoubtedly an important factor in creating the modern trend toward extra high ratings. High-pressure boilers were more expensive than low-pressure boilers, and it devolved upon the designer to get more steam out of each unit of heating surface. The designers have been eminently successful in solving this problem; for the same steam output, a modern 450-lb. boiler plant costs less to build than the reproduction cost of a typical 200-lb. plant of fifteen years ago. Except that there has been a material increase in the consumption of auxiliary power, the efficiency of this modern high-pressure low-cost plant is quite as good as that of its more expensive predecessor. The lower cost has been obtained by forcing the boilers to produce 15 to 30 lb. of steam per sq.ft. of heating surface per hour, whereas 7.5 lb. per sq.ft. was regarded as high production in the older plant. This has reduced the unit cost, not only of the boilers, but also of the settings, foundations, and building. Efficiency has been maintained by equipping the boilers with economizers and air heaters, which are cheaper forms of heating surface, for obtaining low exit flue-gas temperature. While the designer has solved his problem, the solution has created new problems for the boiler room engineer.

One of the first problems arising from the combined effects of higher steam pressures and higher rates of heat transfer was feed-water purification. Formerly feed-water treatment was a minor problem. We were content to accumulate a moderate amount of scale in boiler tubes, and to turbine them at regular intervals. In many sections satisfactory purification was obtained by use of soda ash and sometimes a little lime. With higher pressures and higher rates of heat transfer, this simple procedure became inadequate.

Calcium sulphate is the most troublesome scale forming salt in the majority of our boiler feed waters. This has the property of decreasing solubility with increasing temperature, at least in the temperature ranges prevailing in power boilers. Higher steam pressure therefore had th effect of increasing the quantity of sulphate precipitated. This was aggravated by increased rates of evaporation, since two to four times as much water was evaporated in each tube. Moreover, the combined effect of higher temperature on the water side of the tubes and higher rates of heat transfer through the metal of the tubes, made the accumulation of any material thickness of scale intolerable.

It was observed, early in the development of such boilers that small amounts of scale would cause the tubes to sag and blister. This was particularly true in the radiant heat absorbing surface, the relative quantity of which was much greater than in the older type of plant. The modern plant would never have been practicable without the water-cooled furnace, the slag screen, and other additions to the radiant heat absorbing surface. These new developments simplified the maintenance of furnaces, but increased the importance of correct feed-water treatment.

In a large number of central stations, evaporators easily supplied scale-free make-up. This was a new

device to the majority of operators, and was found troublesome by many. To produce the desired quality of water, an evaporator must be as carefully managed as the boiler itself. In some localities the raw feed must be pretreated; in every case careful attention must be paid to such details of operation as water level, rate of evaporation, and blow down, in order to prevent foaming, carry-over, and consequent contamination of the condensate.

In the majority of industrial plants, with large percentages of make-up, securing scale-free water was a more complicated matter, but the chemical engineers have provided the means of obtaining it. Treatment may be simple or complicated, according to the quality of the raw water, but satisfactory softening can be accomplished chemically, except in very unusual cases.

Elimination of Scale Brings New Problems

Coincident with getting rid of boiler scale, two new problems arose—corrosion and embrittlement. Both had been experienced in the older plants, under unusual conditions, but with the new feed-water treatment their occurrence became frequent and widespread. These problems also have been solved, in part by the chemists, and in part by the equipment designers.

Corrosion may be occasioned by incorrect chemical treatment, but the presence of oxygen in the water is a more common cause. In the earlier plants, slight scale formations protected the metal from corrosion. In some of the older operating manuals, operators are instructed to use raw water for filling boilers, in order to produce a protective coating of scale when starting up. At least one protective coating has been developed which is an effective substitute for the old time scale, wherever it can be applied. It is impracticable, however, to cover all of the surfaces in a boiler plant which comes in contact with feed water or steam. Moreover, corrosion is a chemical reaction and takes place more rapidly at elevated temperatures.

The only way that serious corrosion can be avoided is first to maintain correct feed-water treatment, and then to deaerate the feed water and to keep it deaerated. Management of deaerators is usually simple. It is sometimes more difficult to prevent contamination of the feed water after it leaves the deaerator. Leakage at pump glands and in suction piping, as well as the addition of undeaerated water at other points in the feed system, sometimes cause corrosion, in spite of perfect performance by the deaerator.

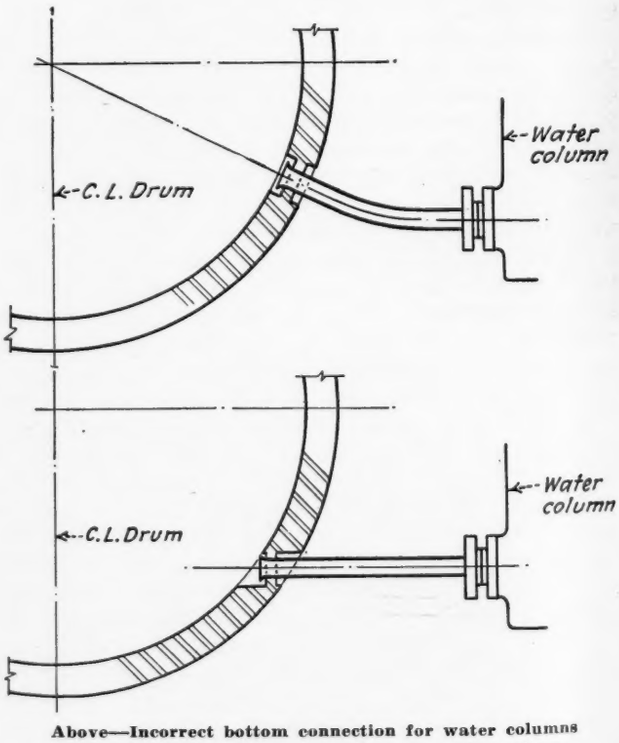
Elimination of Scale Brings New Problems

While embrittlement is as much a matter of boiler design and fabrication as of chemical treatment and while the boiler manufacturers have done their part to reduce the hazard, it has been found that embrittlement can be entirely inhibited by correct chemical treatment of the boiler water. With inside calked joints, or with forged or welded drums, it is thought that the danger of embrittlement is not serious. In view of the value of the property at stake, however, it is wise to treat the feed water in such a way that this hazard is entirely removed.

Ten or fifteen years ago, "hardness" was the only technical term, in regard to feed-water treatment, which the average boiler plant operator needed to know. If he were erudite, he would distinguish between "temporary hardness" and "permanent hardness." Now he has added at least three important terms to his vocabulary—"pH value," a measure of the acidity or alkalinity of the water, "sulphate-alkalinity ratio," which determines the degree of embrittlement inhibition, and "oxygen content." All three must be maintained within prescribed limits, in the modern high-pressure, high-rating plant. While it is usual, even in relatively small plants, to employ a chemist to control feed-water treatment, the boiler room engineer cannot shift all of the responsibility onto the shoulders of a young technician. Successful operation is not merely a matter of analyses and chemical feed; it requires painstaking attention to the operation of deaerators, maintenance of condenser tubes, management of evaporators, disposition of drips, control of blowdowns, and many other details which are straight operating problems which require no knowledge of chemistry, but which do require a knowledge of the fundamental necessity of clean, noncorrosive feed water. When no chemist is continuously available, an understanding of the problem by the men in charge is even more essential.

Temperature Stress and Creep

There has been some difficulty with radiant heat absorbing surface, even when boilers are operated entirely without scale. "Temperature stress" and "creep" are two other recent additions to the boiler operator's vocabulary. If no part of the boiler-tube metal ever got hotter than the water which it contains, no appreciable creep, no sagging, and no blistering would occur in a clean boiler. The fire side of a tube must be hotter than the water side, because it requires temperature head to force heat through the metal. The greater the quantity of heat forced through the metal, and the greater the tube thickness, the greater the temperature head required. This difference in temperature of the outside and inside surfaces of the tube, with the resulting difference in expansion, produces "temperature stress." When high-pressure boilers, with their relatively thick tubes, are forced to high ratings, the difference in temperatures may be considerable, and the temperature stress may exceed the stress due to internal pressure. Pressure stress is the only stress taken into account in the ordinary for-



Above—Incorrect bottom connection for water columns
Below—Correct bottom connection for water column

mulae for determining strength of tubes and shells. Therefore, the combination of pressure stress and temperature stress may exceed the elastic limit of the metal, resulting in gradual but continuous swelling or sagging of the tubes. When this temperature stress is more localized, it results in a local swelling, or blister.

When flame licks a slag screen, or impinges directly on a tube, blistering may occur. This is not exactly the same condition as that described above, but arises from heat being applied to the metal faster than the water or steam can take it away. The remedy is a matter of combustion control. When tubes sag gradually, there may be nothing the operator can do except to keep the output of each boiler as low as possible, by equal division between all boilers, and also to keep the furnace temperature low, by liberal use of excess air, at high ratings. The latter course may be impracticable, because of its effect on superheat, on account of draft limitations, or for other reasons beyond the control of the operator. Above all, the operator should carefully watch the progress of swelling or sagging of the tubes, and replace them before safe limits are exceeded. Fin tubes which check or crack should also be carefully watched, because cracks in the fins may eventually penetrate the walls of the tube.

There is another kind of temperature strain which does not receive the attention it should, and that is the strain which occurs while metal is being heated. Most modern boiler units are "quick steamers," and operators sometimes boast that they can get up full pressure on a cold boiler in a very short time. With thick drums and thick forgings quick heating may result in serious temperature stresses. In the forge shops, when these thick drums are fabricated, temperature of the metal is not allowed to rise at a faster rate than 100 deg. F. per hour. The boiler operator, who uses the same degree of care as the manufacturer, would take four hours to put full pressure on a 450-lb. boiler. It is an interesting stunt, to put such a boiler on the line in twenty minutes, but it is not conservative operation, and should be avoided except in emergencies.

This glass, although broken into more than a hundred pieces, held together

Creep, or a gradual stretch, occurs in steel, under a combination of high stress and high temperature, even when the elastic limit of the metal is not exceeded. When we first began to use steam temperatures in excess of 500 and 550 deg. F., it was found that cast iron "grew," as a result of continued high temperature. Cast iron was gradually eliminated from boilers, piping, and machinery parts which came in contact with the high temperature steam. Now that steam temperatures in excess of 800 deg. F. are being adopted, the creep of steel must be faced. While special alloys may give some relief, the effective way to combat it is to keep stresses so low that creep occurs slowly.

The tendency of steel to creep, or stretch, at high temperature makes the control of superheat much more important in this era of high temperatures. When plants were designed for 600 or 700 deg. F. total steam temperature, a temporary rise of 50 deg. F. due to delayed combustion, or slag in the tube bank was not serious. In a plant designed for 825 deg. F., an excess of 50 deg. F., even for a short period, may be serious.

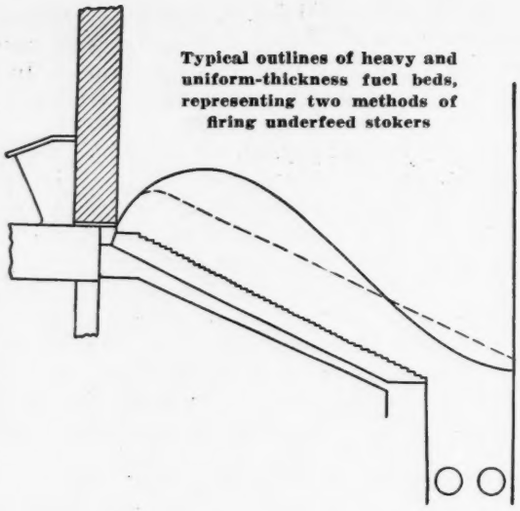
By the ordinary laws of physics, the water level should be more stable, in high-pressure boilers, than in low pressure boilers. Likewise, there should be less tendency to foam, or carry over water and solid matter into the superheater, pipe lines, and prime movers. Actually, there has been much trouble from this source in many high-pressure plants. High rates of steaming and insufficient blow down are usually the cause, although the tendency to economize on metal in high-pressure jobs sometimes persuades the designer to make the boiler drums too small for the separation of water and steam. When such a condition occurs, it accentuates the care which must be given to feed-water treatment, water-level regulation, and blowdown control. Various forms of separators may be used, and may be essential in some cases, but no form of separator will entirely relieve the operator from careful attention to these details.

False Water Levels in High-Pressure Boilers Easily Explained

There have been many cases of false water levels shown by high-pressure gage glasses, but in the cases known to the author, there has been no mystery about it. At very high pressures, the difference in specific gravity between the hot water in the boiler drum and the cooler water in the water column is considerable, and should be allowed for, in reading the glass. For pressures up to 750 lb., this difference is not sufficient to cause trouble, but it is well to bear in mind that the actual level may be slightly higher than that indicated by the glass.

In a few instances, the standard practice for water column installation has not been followed, sometimes to save money, and sometimes in a misdirected effort to get a better job than standard practice requires. In one of the early high pressure plants, the designers had the commendable desire to avoid screwed or welded joints in the forged boiler drum. With approval of the insurance company and the state authorities, the water column connections were rolled into the drum, as shown in the sketch. It will be noted that the bottom connection does not drain toward the drum; as only condensate was to be used for feed water, and as the water-column blow down would drain the connection to the boiler drum, no trouble was expected. Trouble did develop, however. It was corrected by changing the bottom connection as shown. Clever detail, in designing the connection, made it possible to comply with the Boiler Code without sacrifice of the original high standards of design.

The difficulties originally expected with the gage glasses on high-pressure have seldom developed. It was known that high temperature water etches glass and, from the beginning, high-pressure boilers have been equipped with flat glasses, lined with mica. The mica is gradually dissolved, and must be replaced at intervals. A good grade of glass, carefully installed so that it may expand without undue restriction, will last indefinitely. When a good quality flat glass does break, or shatter, it rarely flies, like the older round glasses. Sometimes they do not even leak, and have to be replaced only because they became opaque when shattered. The photograph shows a glass that is actually broken into more than one hundred pieces, but which held pressure for several minutes before the gage glass was shut off.



Typical outlines of heavy and uniform-thickness fuel beds, representing two methods of firing underfeed stokers

Factors in Successful Stoker Operation

Selection of proper type and size of unit, and maintaining of uniform and proper thickness of fuel bed are important. The trend is toward use of thinner fires and higher induced draft with underfeed types. Use of water walls and preheated air affects maintenance cost

WITH stokers now available in types and sizes for practically any size of plant and kind of coal, the first step in obtaining satisfactory operation of a stoker unit is essentially one of selecting the proper type for the operating conditions to be met and the kind of coal to be burned.

The coals throughout the country possess widely differing characteristics, requiring conditions peculiar to each particular coal for the best combustion results, and while some types of stokers may burn practically every coal with some degree of success no stoker should be expected to operate successfully with every coal. In cases where stokers have failed to meet expectations the failure has usually been due to improper selection rather than to any inherent weakness in the stoker.

If there are sudden overloads or peak conditions, obviously a forced-draft unit should be considered. On the other hand, if the load is fairly uniform and it is not intended to operate the boilers much above normal rating a natural-draft type may be preferable. Where the coal is free-burning, with comparatively little coking tendencies, overfeed or chain-grate stokers are best-adapted; while if the coal is a low-grade product or a small-size anthracite a forced-draft chain or traveling grate is desirable. If, however, the coal is of a medium or heavy coking variety, as are most of the Eastern bituminous coals, an underfeed stoker, which is essentially a forced-draft unit, should be used.

One of the chief operating difficulties common to all types of stokers is that of maintaining a uniform fuel bed over the entire grate surface. This problem, however, is minimized through proper preparation of the coal before passing to the stoker hopper and guarding against segregation in the stoker hopper. The best size of coal is that having the largest percentage crushed to pass through a $\frac{3}{4}$-in. round mesh screen, with the maximum size passing through a $1\frac{1}{2}$-in. round mesh screen.

Segregation of the coarse and fines in the stoker hopper has a decided effect on the fuel bed. If the coal is allowed to flow normally out of a round spout into the stoker hopper it will probably form in peaked-up piles with the large lumps on the outside and the fines in the center. Where this condition obtains there will be a distinct segregation of fuel particles on the stoker, causing thick and thin lanes in the fuel bed. Segregation in the hopper has been overcome in a number of ways, by widening the end of the coal spout parallel with the stoker hopper, by use of a swinging spout operated mechanically from the stoker crankshaft, and by the application of a mechanical spreader in the hopper.

Fuel Bed Thickness With Chain Grate

With a traveling-grate stoker it may be said that, in general, the best and most economical fuel bed thickness to maintain at all ratings is the thinnest one which will permit of carrying the load without danger of losing ignition or blowing excessive amounts of fuel off the grates or causing holes in the fire. Variations in the rating can best be obtained by increasing or decreasing the grate speed and air flow, with little or no change on the fuel bed thickness. Generally a fuel bed should be maintained whose thickness gives the best results at the normal rating at which the stoker usually operates. This fuel bed thickness should be varied only when it is found that change of grate speed is not sufficient to obtain the desired rating. A thick fire and slow speed may give slightly better results than a thin fire and high speed, but greater burning of the grate is likely to occur.

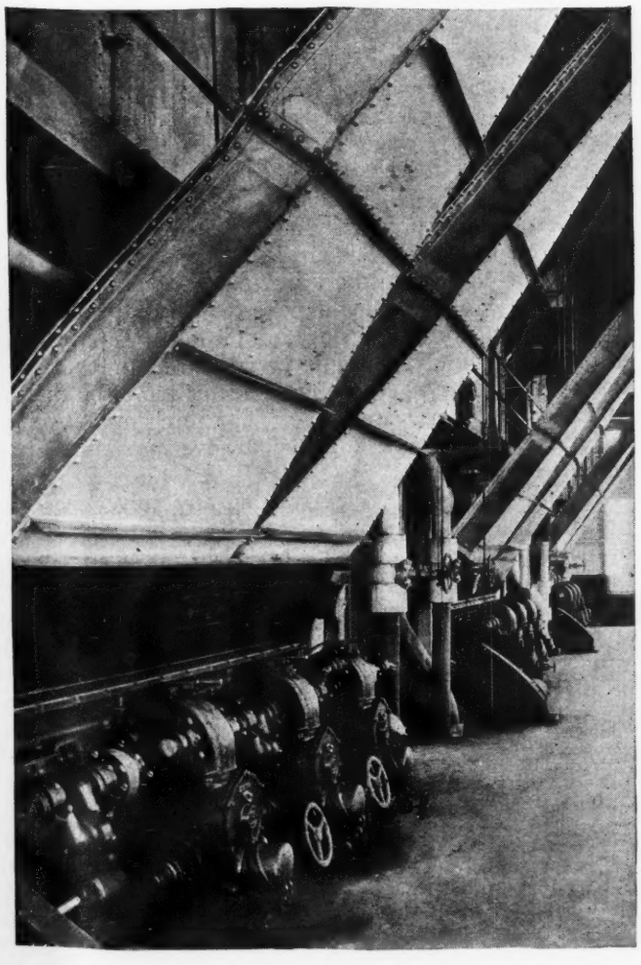
Windbox pressures to be used with a traveling-grate stoker depends upon the kind and size of the coal, the type of setting, fuel bed thickness and combustion rates. In general the windbox pressure should be gradually decreased from the second compartment to the rear air compartment. With bituminous coals it is generally necessary to maintain a lower air pressure in the first compartment than in the second.

With underfeed stokers of the multiple-retort type the

outline of the fuel bed is of utmost importance. It must be maintained correctly to meet load demands effectively and efficiently. Over the tuyères a fuel bed of 24 in. is considered heavy, 18 in. is about normal and a bed thinner than 15 in. is considered light. These thicknesses apply to a point about 22 to 24 in. inside the front wall. While the fuel bed of an underfeed stoker must necessarily be much heavier than that of any other types both capacity and efficiency are decreased by carrying too heavy a fire. If the fire is permitted to become too heavy at the rear end serious clinker trouble may result. On the other hand, the fuel bed must not be carried too thin at the rear, as this practice tends to cause the formation of holes, which introduce an excessive amount of air into the furnace.

Although the most general practice with multiple-retort underfeed stokers is to carry a fuel bed with an outline about as shown by the heavy line in the drawing and to operate with a balanced draft or a slight negative pressure in the furnace and a high windbox pressure, there is a trend toward the use of thinner fires (shown by dotted line) and higher induced draft. Arguments in favor of the thinner fire and higher induced draft are: more effective use of the grate area, improved combustion due to improved distribution of air through the fuel bed with consequent increase in the steaming capacity of the boiler, and reduced maintenance. It is further claimed by the proponents of this method of firing that the thinner fuel bed is of a different character to that of the thick, offering more and smaller openings, and consequently gives better mixing of the air, coke and gas and allows the air to pass through the bed with a smaller pressure drop for the same volume.

Cleanliness and good illumination in the boiler room promote efficient operation of stoker units



Pressure under the grates of an underfeed stoker depends upon the same factors as with a chain grate. By observing the condition of the fire, it is not difficult to determine the draft that will produce the most efficient results. This is more accurately determined by the use of draft gages, air-flow, steam-flow meters, CO_2 meters and exit-gas thermometers. The lowest pressure that will give the correct mixture of air and fuel should be used at all rates of combustion. When conditions demand more steam, both air supply and coal feed should be increased, and vice versa.

Economical Amount of Excess Air

After a certain point is reached, decreasing the excess air increases the loss from incomplete combustion as indicated by CO in the flue gas. Decreasing the excess air also decreases the volume of stack gases, so that the loss in the flue gas is reduced. Increasing excess air produces opposite conditions, and it is a question of balancing a loss against a gain and operating with the amount of excess air which is determined to be the most economical.

Where economy is the chief consideration the rating at which the stoker will give maximum efficiency should be determined, and then each unit should be operated at as near the maximum efficiency as possible. Where fluctuating loads are to be handled a little foresight to meet changing conditions will result in substantial savings. The fire should be built up to meet expected peaks and the fuel allowed to burn down just previously to cleaning time.

Operating experience has shown that one of the best ways of keeping a stoker in proper working condition is to establish a detailed inspection at regular intervals. In plants where the maintenance is held at the low figure of 3 to 4c. a ton, the general practice is to inspect the stoker thoroughly every three to four months and give it a complete overhaul once a year. At the overhaul period all tuyères that have been burned sufficiently to seriously change the ratio of heat-absorbing to heat-liberating surfaces are renewed. Badly burned tuyères not only greatly reduce the fuel burning capacity of the stoker, but generally have the air passages so restricted that further burning is inevitable.

Efficiency Maintained Through Improvements

In ordering new parts for a stoker advantage should be taken of any improvements made by the manufacturer. In this way not only will the efficiency of the stoker be improved, but the cost of maintenance will be lowered through the use of improved heat-resistant materials and improved design and methods of assembly.

When putting a stoker into service after a general overhaul it should be operated for a short time at slow speed, then at full speed with maximum stroke on the secondary rams and other reciprocating parts. This precaution will frequently obviate an interruption after the stoker is in service. Use of water-cooled furnace walls and preheated air have considerable influence on stoker maintenance. Water-cooling of the rear wall is particularly advantageous, owing to the cooling effect on the lower end of the stoker. A limited amount of preheat tends to reduce maintenance through the ability to maintain better fuel bed conditions.

Accepted Practice in Pulverized-Fuel Firing

Successful operation of pulverized-fuel plants largely depends on proper training of operating personnel. Adoption of improved methods of igniting fires reduces danger of blowbacks. There is need for more general observance of safety rules

AT THE present stage of the art of firing boilers with pulverized coal, using either of the two systems (bin-and-feeder and direct firing) now in general use, few difficulties are experienced in normal operation, providing the equipment is intelligently operated and given the proper care in service. As a result of recent improvements in pulverizer design, mills can now be operated continuously for long periods without shutdown. Therefore, the problem of securing reliable and dependable service from this type of combustion equipment is essentially one of proper training of the operating personnel.

A survey of operating methods in a number of industrial power plants using pulverized coal would seem to indicate a need for the more general adoption of the improved methods of igniting fires in cold boilers, as well as a need for more general observance of certain precautionary measures in handling the equipment.

The old-time method of igniting fires, that of using an oil-soaked ball of waste on a rod pushed through an opening in the furnace wall adjacent to the burner, cannot be too strongly condemned. A torch of this type has comparatively little volume or flame spread and is likely to give slow or retarded ignition, with consequent danger of a flareback or explosion of considerable intensity. It should be appreciated that the same condition that causes a small puff can also cause a serious one, it being simply a matter of seconds in delayed ignition.

One of the best methods of igniting pulverized-fuel fires is the use of an oil or gas torch incorporated in the burner, the torch being so arranged that it can be withdrawn from the hot zone when ignition has been established. With burners where no provision for a torch has been made, an opening for the torch should be provided in the wall of the furnace directly below, or adjacent to, the coal inlet. If the burner points downward through a flat or inclined arch, satisfactory ignition may be effected by placing the torch in the front furnace wall a short distance below the burner or through an opening in the arch parallel with the burner.

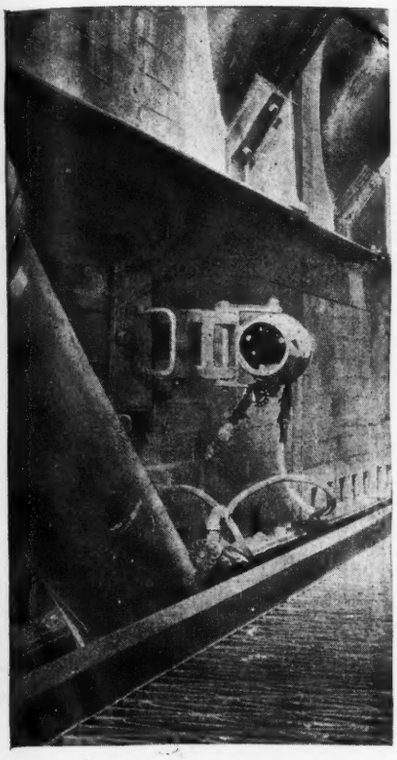
In smaller plants where the complete installation of oil torches with the necessary auxiliary equipment would not appear to be justified, and gas is not available, good results can be had with a standard form of portable kerosene torch, the necessary pressure for atomization being supplied by compressed air. The essential requirement of any igniter is that it give a high-temperature flame of large volume, with a spread sufficient to give maximum contact with the coal stream.

Although the practice of lighting pulverized-fuel fires must necessarily change somewhat with the general arrangement of the equipment employed, there are certain definite rules which should be followed and which can be applied to practically any type of furnace.

Before any attempt is made to supply coal to the furnace or light the torch and place it in position, a definite flow of air should be established through the furnace by starting the induced-draft fan. With the fan in operation the draft should be adjusted to give a suction, at the point where the gases enter the boiler tubes, of around 0.15 in. water gage. The torch may then be inserted and the flame adjusted to give maximum temperature and volume.

It is most essential when starting any pulverized-fuel fire, regardless of the kind of coal being burned or type of burner employed, that a very rich mixture be used until stable ignition has been established. This rich mixture of coal and air is obtained by using a minimum amount of primary or carrier air at the feeder or pulverizer. If a unit mill is used the amount of air should be the minimum made possible by the requirements of the pulverizer to prevent plugging up.

The sequence of starting the equipment to supply the fuel to the furnace will vary with the type of equipment employed. With a unit mill in which the feeder, pulverizing element and fan are driven as a unit, the mill is brought up to speed with the coal feed shut off and the mill dampers set to give minimum amount of primary air until the fire is ignited. When the mill is operating at full speed, and before the coal feed is started, the



Fuel oil igniter hinged to boiler front directly below burners, shown (at left) in igniting and (at right) in withdrawn positions

furnace draft should again be checked and readjusted to compensate for any change brought about through starting of the pulverizer. When this has been done the coal feed may be started at a rate equivalent to three-quarters to full pulverizer capacity, care being taken not to plug the mill during the period of restricted air flow through it in order to obtain a rich mixture.

With certain types of mills it is not advisable to run the mill for any length of time without coal, in this case the feeder should be started simultaneously or just previously to the mill.

If for any reason ignition does not take place immediately (within 10 sec.) upon admitting the coal and primary air to the furnace the coal feed should be stopped at once by either stopping the feeder or shutting down the pulverizer. Before again attempting to admit fuel to the furnace the combustion chamber should be cleared of coal by operating with a high induced draft (0.25 to 0.35 in.) for at least two or three minutes. At the end of that time the draft should be brought to normal and the lighting-up procedure repeated.

When positive ignition has been established and the coal is burning properly the forced-draft fan may be started and final adjustment made to the coal feed and air dampers to give the desired rating on the boiler. Following this, the ignition torch, if integral with the burner, should be drawn back out of the heat zone (and if external it should be withdrawn completely from the furnace) unless specially designed for permanent installation.

Most of the recent unit pulverizer installations have been arranged for forced-draft firing. Experience has shown that forced draft produces greater turbulence and more complete mixing of secondary air with the primary mixture than is possible with natural draft. It is more susceptible to easy and quick control and more adaptable to automatic control, affording greater flexibility in operation. It also provides means for obtaining and maintaining any desired CO_2.

In plants using the bin-and-feeder system the pulverized-fuel bin, air transport, screw conveyor and transport lines require some attention in service.

Experience has shown that pulverized coal should not be allowed to stand in the bin more than a week, although as the volatile content decreases the period of storage may be increased. As a safeguard against fires breaking out in pulverized-fuel bins the bins should be emptied at frequent intervals and filled with fresh fuel. If any cleaning is necessary before the bin is refilled, precaution must be taken against the possible presence of CO by allowing air to circulate through the bin for several hours before a workman is permitted to enter.

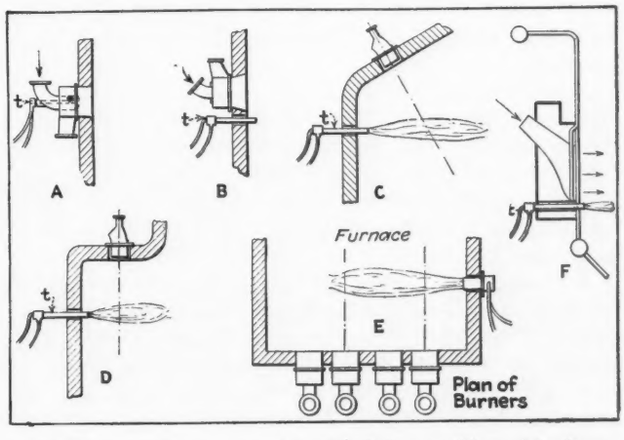
Air transport pumps require ordinary attention to lubrication and inspection of the screw and air ring at intervals of two to six months to determine wear on screw and if air holes are clear. The moisture in the coal is a factor in the wear on pump parts, a moist coal being more active in its corrosive effect. Experience with transport lines indicates that they require no inspection or attention other than that to valves and any automatic switches and relays that may be employed.

In screw conveyors the most important items are the radial and thrust bearings. These should be inspected at intervals of one to four weeks. This work is facilitated by having small handhole covers fitted to the regular conveyor cover directly above the bearings.

Drying of the coal in the mill by preheated air has become general practice. This preheated air is obtained by passing the air from the forced-draft fan through passages in furnace walls and bottoms, by waste-gas air heaters or independent steam air heaters.

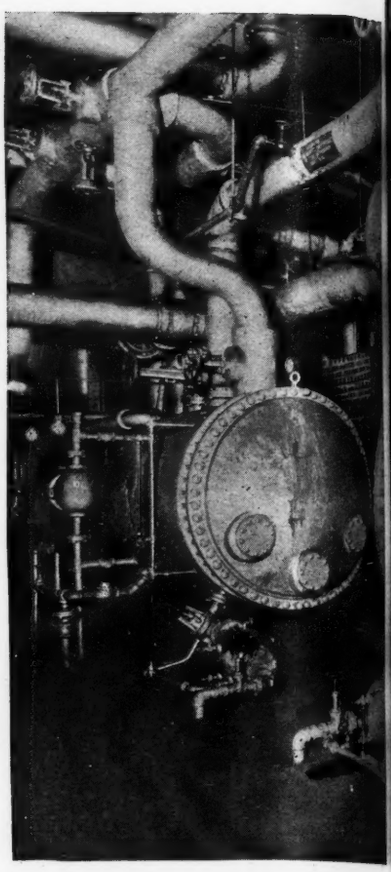
The amount of preheated air required for drying depends upon the moisture in the coal. General practice is to maintain a temperature of air and coal discharge from the mill of about 150 deg. Where a separate steam heater is used it is usual practice to heat a smaller quantity of air to a higher temperature and temper it with room air at the mill inlet.

As the amount of ash going to the stack in a pulverized-coal-fired plant may run as high as 80 per cent of the total ash in the coal, it is imperative in some industrial installations that some form of collector be employed to remove the fly ash. The equipment now available for this service includes cyclone collectors, bag filters, wet washers and electric precipitators, and the efficiencies, in terms of the per cent of total ash removed, range from 50 to 90 per cent. A tendency is noted toward the development of slagging furnaces designed to catch and hold a much larger proportion of the ash than is held by the dry-ash type of installation.



Typical burner arrangements and relative position of igniters

Fouling, air binding and flooding are the chief troubles with closed heaters, but are easily avoided or remedied. The primary problems with evaporators are blowdown, priming and descaling. Progress had been made along all of these lines. Feed-water regulators face many problems, some never completely solved



Two 48-in. evaporators supply distilled water to the boilers of a large steel company

HANDLING Closed Heaters, Evaporators

OPERATION of three loosely related elements of the feed system—bleeder heaters, evaporators and feed-water regulators—is taken up in this article. Feed-water treatment by chemical means and by continuous blowdown is discussed in another article in this number.

Closed Heaters

In the operation of closed feed-water heaters there are three things to look out for, all of which involve heat transfer: fouling (inside or out), air binding and flooding.

A feed-water heater may be fouled by scale or dirt on the inside of the tubes (water side), or by oil on the outside, where the exhaust, improperly purified, comes from reciprocating units. At times carbonates are condensed from the steam on the outside of the tubes. The remedy in all cases is purification of the water and steam.

A heater may become air bound because of improper venting. Vents should be at the point of the shell most remote from the steam inlet and nearest the coldest water, so that they will be cooled. The vents can blow into the air, or can be "cascaded" through other heaters at lower pressure.

Flooding of closed heaters, due to failure of drainage, is a frequent occurrence. The drain may be too small, or the trap too small, or they may become clogged. A gage glass on the heater will immediately reveal the presence of flooding.

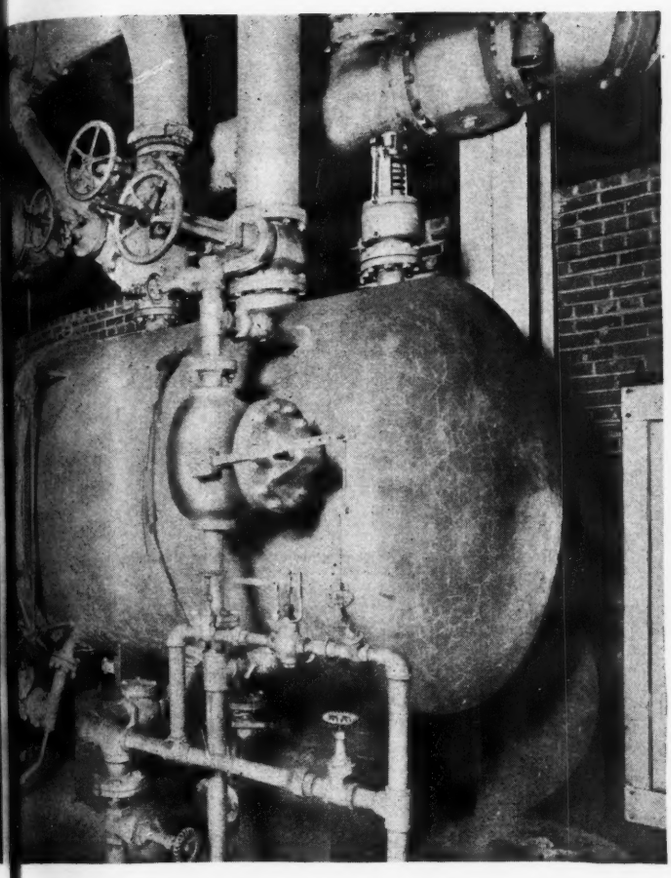
Thermometers at the inlet and outlet of the heater will indicate one of several defects, by failure to show proper rise of temperature of water passing through the heater. This may be due to fouling, to air binding or to flooding.

It frequently happens that water leaks into the steam space. Such leaks are quickly detected if a condensate meter is used on the heater. If leaks exist the "condensate" will be greater than the amount of steam required to heat the given quantity of water through the given temperature rise.

Bursting of tubes in a bleeder heater may lead to bursting of the shell if there is not adequate provision for release. A relief valve should therefore be provided on the shell, large enough to handle one-fifth the cross-sectional area of all the tubes.

Descaling and Priming Are the Chief Operating Problems With Evaporators

In central stations, and in industrial plants where the percentage of make-up is not high, evaporators are widely used as a means of producing feed water of



and Feed Regulators

exceptional purity. The impurities that are removed from the water by the evaporator are deposited as scale on the tubes, precipitated as mud and sludge, or left in solution.

To keep the sludge and dissolved solids from accumulating beyond a certain point, it is necessary to blow down the evaporator, either intermittently or continuously. Continuous blow-down permits the application of heat interchangers, with the recovery of much heat that would otherwise be lost. Practically all commercial feed-water evaporators of modern design have the steam within the tubes and the water to be evaporated on the outside.

Scaling Evaporators

The normal method of removing scale is by a sudden change of temperature, which may be produced in various ways, depending upon the make of evaporator and the type of installation. In one method the first step is to shut off the water supply and drain the evaporator. Meanwhile, steam pressure is kept on the tubes, with the vapor outlet shut off. A relief valve prevents excessive rise of vapor pressure. This gets the scale very dry and hot. The steam is then turned off and cold water is shot into the vapor space very rapidly. Steam is then turned on to produce rapid boiling, which cracks off the scale. The cracked scale is then removed by blowing down the evaporator.

Another widely used sequence is as follows: Steam and water are shut off. The evaporator is blown down. Water is then admitted very rapidly through a bypass around the feed valve. Finally, the steam is turned on. This sequence is repeated once.

Priming Prevented

Some years ago there was complaint regarding the tendency of many evaporators to prime, particularly under highly fluctuating loads. It is now possible to obtain equipment that will give little or no trouble in this respect. However, in operating an evaporator the water level should be kept at the lowest point which will maintain capacity, since high level may cause priming. With evaporators now available the carryover, under worst conditions, should never exceed one-half grain total solids per gallon, and should generally be much less.

Feed-Water Regulators

As a piece of equipment, the feed-water regulator has been developed to a high state of perfection. It suffers, however, from some limitations inherent in the system and in the boiler. A good feed-water regulator, considered as a mechanism, should give little trouble, except that the stop valve should be replaced or repaired every three to five years.

Yet in many plants trouble is experienced with erratic water feeding. Smooth level of water may go with erratic flow, or erratic level with smooth flow. Of the two, it is generally much better to keep the feed flow in proportion to the steam flow, and to allow the water level to fluctuate somewhat. One reason that smooth water level is not necessarily desirable is that it does not mean a constant weight of water in the drum. When the rate of steaming is suddenly increased the density of the mixture of steam and water is greatly reduced, and the water level rises without any increase in the weight of water in the drum.

Regulator Should Not Be Too Large

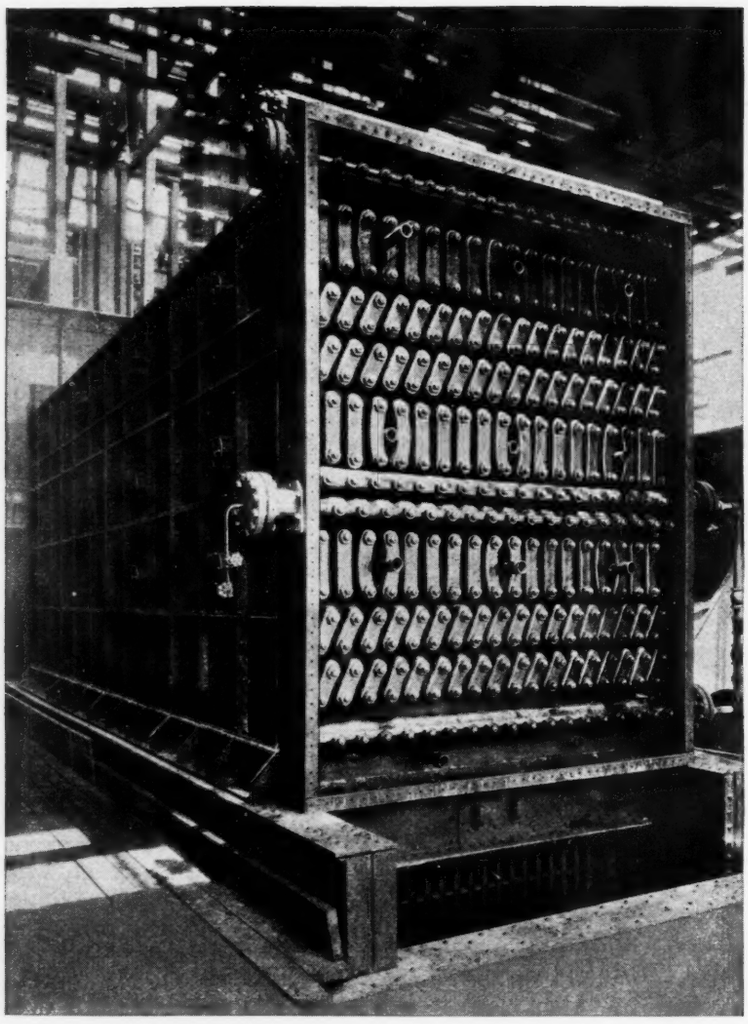
The chief difficulties with feed-water regulation occur with large boilers, particularly those with water walls. Very frequently the trouble is due to the installation of too large a regulator, and is aggravated by variations in pressure at the feed-water end of the boiler. The latter may be eliminated by the use of an excess-pressure regulator, which will greatly improve the action of the feed-water regulator.

If the designer has information as to the feed supply pressure and all about the installation he can generally furnish a regulator that will operate satisfactorily. If, however, too large a regulator has been installed, through mistake, the fault can often be corrected by putting in a smaller plunger rather than by replacing the whole regulator. Good combustion control helps greatly to give good feed control.

It goes without saying that regulators with a radiating element should be installed with the tube within the range of levels through which the regulator is supposed to operate. The valve must function properly—that is, move freely. The regulator must be attached to the same part of the drum as the water glass. If not, wide differences in level may occur.

Corrosion:

A PRIMARY PROBLEM



Economizer mounted directly above air heater, top of which is visible

The three chief causes of trouble with economizers and air heaters are corrosion, clogging and leakage. This article is primarily concerned with the cause and cure of these troubles

MOST of the difficulties encountered in the operation of economizers and air heaters are caused by corrosion, clogging and leakage. There is no heat-balance problem in their operation, although heat-balance matters must be carefully considered by the designer in order to apportion heating surface correctly between air heater and economizer.

In operation, the engineer simply sees to it that both economizer and air heater absorb all the heat of which they are capable. An exception to this rule must be made, however, in cases where corrosion results from overcooling of the flue gases or where the air normally delivered by the air heater is so hot as to cause trouble with grates or stokers. These exceptions will be discussed later.

Keeping Economizers Clean

Economizers are subject to fouling and corrosion, on both inside and outside. Fouling on the inside is due to scale, and is easily prevented by the same water treatment that will prevent formation of scale in the boiler. Outside fouling is due primarily to soot and dust from the flue gases. This is normally removed by soot blowers or (on smooth-tube cast-iron economizers) by automatically operated scrapers.

In addition to using the soot blowers, it is common practice to hose down the outside of economizers from time to time.

Accumulation of soot and dust on the outside of economizer tubes is harmful to operation in two respects. First, it reduces the amount of heat delivered to the feed water, and, second, it increases the draft loss, putting more load on the induced-draft fan.

Both of these effects are easily measured by thermometers and draft gages, respectively, and these measurements can be used as a guide to cleaning periods.

The internal surfaces of an economizer should be inspected at periods determined by experience, to remove the mud and the scale. If scale forms in excessive amounts the system of feed-water treatment should be carefully studied.

Corrosion of Economizers

Except where water leaks exist, external corrosion, in economizers as in air heaters, occurs only near the exit of the flue gases, and then only when these gases are reduced below the dew point.

To avoid internal corrosion the feed water should be alkaline, with a pH (hydrogen-ion) value of not less than 10, and contain less than two-tenths of a cubic

WITH AIR HEATERS AND ECONOMIZERS

centimeter of oxygen per liter. To keep the oxygen below this point it is necessary to use a deaërator. This, in turn, will require inlet feed water of such a temperature that the exit gases will probably not be cooled below the dew point and will therefore not cause external corrosion.

Both external and internal corrosion are commonly more severe on steel than on cast-iron surfaces.

Leakage Must Be Stopped Quickly

Aside from internal and external corrosion and fouling, the only important difficulties with economizers are leakage of water and of gases. Water leakage is generally due to improper connection of tubes to headers. After a leak is once started it will grow worse rapidly if not corrected at once.

Air leaks into the casing of an economizer tend to lower the exit temperature of the feed water, and to increase the load on the induced-draft fan. Such leaks are easily detected by a falling off of the CO_2 in passing through the economizer. To detect leakage, samples for Orsat analysis may be drawn simultaneously from the gas inlet and exit.

Corrosion and Leakage the Primary Troubles With Air Heaters

Most of the troubles in air heater operation arise from moisture, sulphur and dust in the flue gas, and from leakage between the air and gas compartments.

In this connection the following comments, made to *Power* by a prominent designer of a plate-type air heater, will be of interest:

"Until a few years ago the trend of design in plate-type air heaters was to reduce the width of air and gas spaces in order to get greater heat transfer per square foot. When, however, widths were reduced as low as $\frac{1}{2}$ in. there was much clogging. Present practice favors a space not less than 1 inch.

"With vertical gas passages soot rarely accumulates to a point where it causes clogging. Clogging, on the contrary, comes primarily from an accumulation of ferrous sulphate, which, in turn, is the direct result of moisture condensed from sulphur-bearing flue gases. This ferrous sulphate sets in a concrete-like slab which is extremely difficult to remove. When this trouble exists it is accentuated near the point where the gases leave the air heater.

"The only cure is to keep gas in contact with the plate from getting below the dew point. The dew point depends upon the kind of fuel, particularly its content of hydrogen and sulphur, and the excess air. The temperature to be considered is not that of the mass of the gas, but that of the film in immediate contact with the plate. This is approximately the mean of the average temperatures of air and gas in that section of the heater.

"Cooler inlet air in the winter time lowers the temperature of the gas film far more than it lowers the mean temperature of the exit gas. Again, there may be no accumulation at usual rates of operation, but much during the starting-up period. Reduced ratings lower the temperature of the gas film at the preheater exit, and may bring it below the dew point. Five or six hours at a temperature below the dew point may cause trouble that will cost hundreds of dollars to cure besides the time and inconvenience due to the resulting outage.

Better Too Large Than Too Small

"When purchasing an air heater it is safer to get it too small rather than too large. Heaters are frequently ordered with a 'safe margin' in capacity, which causes much trouble. The air heater should be bought small enough to prevent condensation with winter air at the lowest continuous load.

"With the heater already installed, one cure is to bypass some of the air around the heater. Another is to return some of the heated air to the inlet."

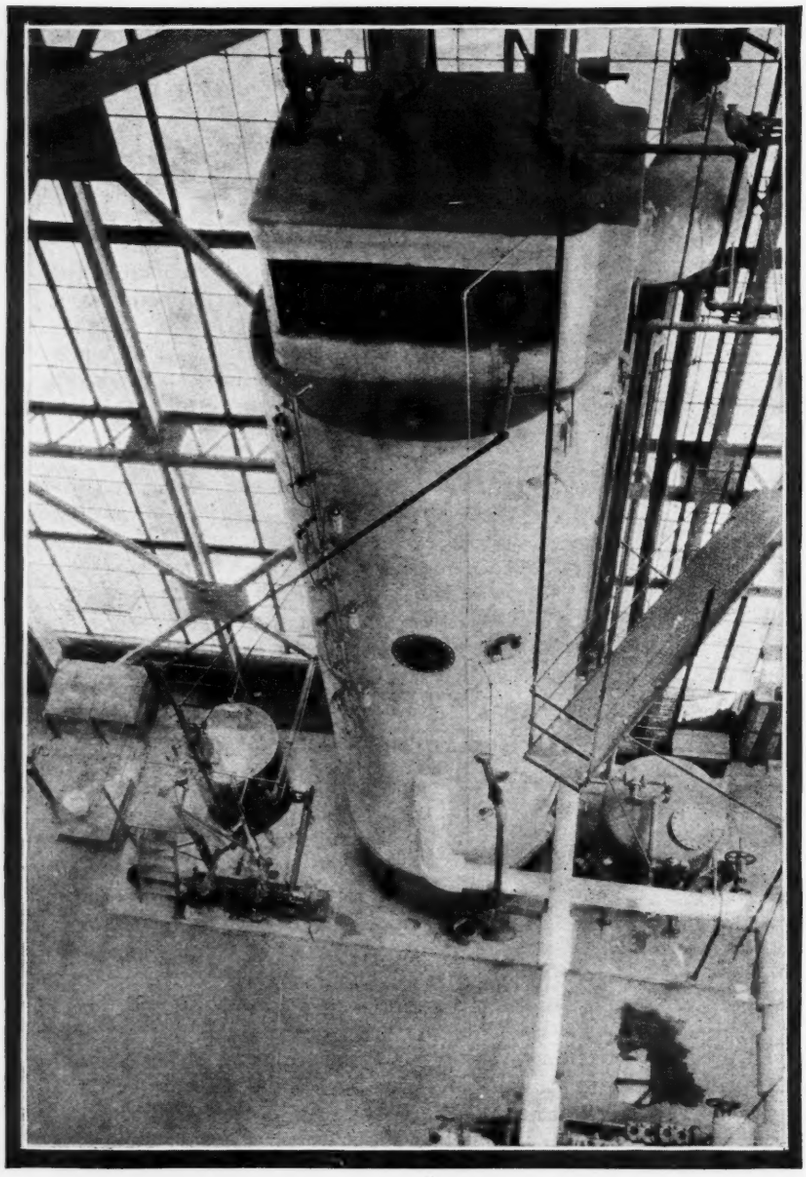
There is some difference of opinion among the authorities as to the advisability of using steam soot blowers for cleaning plate-type air heaters, but all agree that care should be taken in the use of soot blowers to avoid slugs of water. These will set up serious corrosion, especially where a high sulphur coal is used and the banking periods are considerable. Heaters of certain types are normally provided with soot blowers.

Effect of Air Leakage

Air leakage into the gas compartments of air heaters and economizers may be detected by measuring the drop in CO_2 percentage through the air heater. In air heaters of reasonable size this drop should be less than 1 per cent. Care should be taken in checking this leakage to investigate that at the inlet connection, which is often greater than that in the heater itself.

While the foregoing comments are directed specifically toward the plate type of air heater, they apply, in the main, to tubular air heaters. The tubular air heater is, however, more often cleaned by washing. The technique of washing is important if corrosion is to be avoided. The best practice is to wash immediately before starting up, so that the water will evaporate before corrosion sets in.

To sum up, the difficulties encountered with economizers and air heaters are due to corrosion, to fouling and leakage, and to cooling the products of combustion below the dew point. The last is easily prevented by installing a unit that is not too large. Economizer corrosion on the water side can be avoided by deaeration and by maintaining a pH value of not less than 10.



Hot-process softener, chemical proportioner at left

Eliminating Trouble Through Water Treatment

Some of the most difficult problems of plant operation center around the treatment of water, particularly the chemical treatment of raw feed water and the "conditioning" of boiler water

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THE MODERN power engineer has become something of a chemist. Necessity has forced him to find the cause and cure of scale deposits, tube burnouts, priming, corrosion and embrittlement. These problems are the most difficult and troublesome the operating man is called upon to face. The modern cures for these ills may be outlined as follows:

For mud and other suspended matter: Coagulation, settling, filtration.

For hardness: Hot lime-soda process of water treatment, zeolite softening, boiler water conditioning.

For corrosion: Deaëration, addition of alkali.

For priming: Oil removal. Reduction in total solids by controlled blowdown. Water-level control.

For embrittlement: Maintenance of prescribed ratios of sulphate to total alkalinity measured as carbonates. Also maintenance of a definite phosphate content in boiler salines.

The principal chemicals used for the treatment of water are lime (calcium hydrate) and soda ash (sodium carbonate). Caustic soda, trisodium phosphate and other substances are also used. For internal treatment the phosphates in particular are finding increasing use at the present time as a result of the higher pressures.

Chemicals are sometimes introduced directly into the boiler, but, with lime and soda particularly, it is better practice to treat the water in a special tank outside of the boiler.

Hot-Process Softeners

In the hot-process softener the functions of open feed-water heater, softener and sedimentation tank are combined, and a sand filter is often included in the outfit to remove traces of precipitated hardness.

The heat of the exhaust or bled steam supplied to the softener assists in precipitating the impurities and reduces the amount of chemicals required. It also serves, in large measure, to deaërate the water, thus reducing its tendency to corrode. Where bled steam is used the softener becomes an integral part of the regenerative feed-heating cycle.

It is impossible here to go into many operating details of the various makes of softeners. There are, however, certain matters that should be taken care of in any type of hot-process softener. These may be summed up as follows:

The water should be heated to at least 205 deg. F. at all times to promote rapidity of reaction and to drive off dissolved oxygen. The amounts of various chemicals in the feed to the tank must be periodically adjusted to follow the variations in the analyses of raw and softened water.

Particular care should be taken to see that the chemical proportioner does not clog or otherwise fail to work freely and properly, maintaining constant proportioning between chemical feed and water flow. The sedimentation tank must be blown down regularly.

Knowing the relative flows of feed water and chemical solution and (from the water analysis) the lime and soda ash required per thousand gallons of feed water, it is a matter of simple arithmetic to determine the amount of these substances to put into the chemical solution. An agitator is used to keep the lime in suspension. It also helps to dissolve the soda ash.

If this preliminary proportioning has been done properly, the treatment will be approximately correct. It will, however, generally be necessary to modify the treatment according to a test of the softened water. A simple titration test gives certain values known as "Ph" and "MO."

For good results, the MO value may be anywhere between 2 and 3.6. In addition, it is necessary that the MO value be at least double the Ph value, but not exceed double the Ph value by more than 0.3. If the test of the softened water does not fall within these limits, the amount of lime or soda, or both, should generally be adjusted. Charts for determining the necessary changes in chemical feed are furnished by the manufacturers of softeners.

The specified limits of MO and Ph in general insure freedom from scale and corrosion at normal pressures. However, lower ratings may be carried with certain waters, provided the alkalinity of the boiler water, expressed as sodium carbonate, is regularly about 50 gr. per gallon.

Zeolite Softeners

Zeolite softeners are in common use for the softening of boiler-feed make-up water. In this process no soluble chemicals are added to the water. It is passed through a bed of sand-like "zeolite," or base exchange silicate, which has the property of exchanging sodium for the calcium and magnesium hardness molecules. That is to say, the zeolite will turn calcium sulphate into sodium sulphate, and calcium bicarbonate into sodium bicarbonate.

Since all sodium compounds are completely soluble, the treated water is non-scale-forming. It does, however, contain sodium compounds, molecule for molecule, with the original hardness compounds. These are important only as they affect the need for blowdown and the requirement (which is discussed later) for maintaining a certain ratio of sulphate to carbonate.

The water produced is commercially of zero hardness. While it shows a minute amount of hardness on analysis, it gives a negative soap test and deposits no scale.

After the zeolite in a given softener has removed a certain amount of hardness it begins to lose its base-exchange power, and must be regenerated by strong brine of common salt. This reverses the reaction, delivering sodium to the molecules of zeolite and removing the calcium and magnesium from the zeolite.

The capacity of a zeolite softener is stated in kilograins, denoting thousands of grains of hardness commercially removable between regenerations. This capacity is practically independent of the rate of softening.

Zeolite Does Not Deteriorate

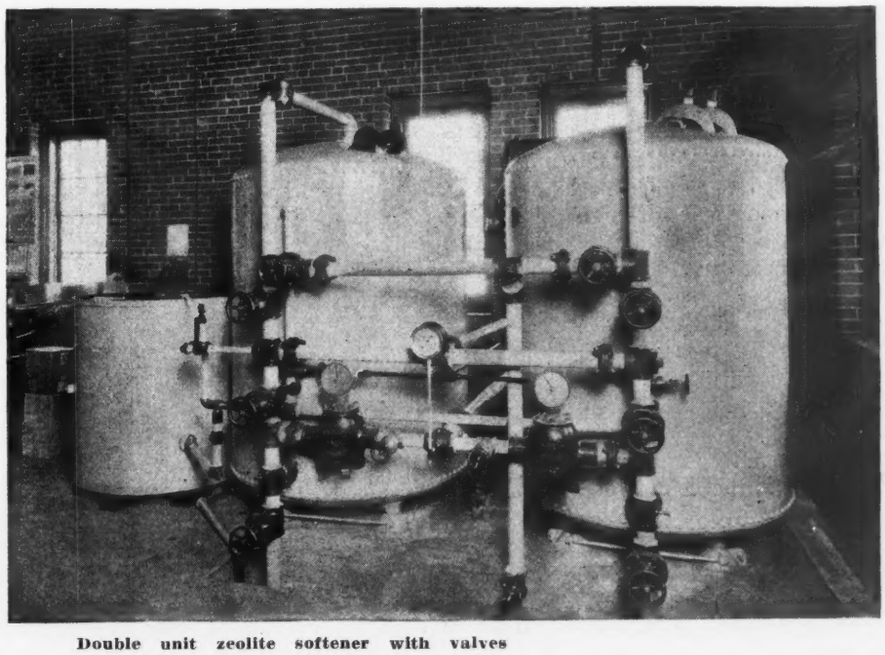
Provisions for the period of regeneration may be made by using a double-unit softener, or one unit and a storage tank for softened water. The zeolite in the softener does not deteriorate with use, but a very small amount (2 to 3 per cent) should be replaced annually to keep the bed up to normal level. Operation above rating will not damage the zeolite but may cause temporary reduction in capacity. To restore the original capacity may require several regenerations, with larger amounts of salt.

It is customary to dissolve the salt in a saturated solution, running about 18½ lb. of salt per cubic foot of solution. Regeneration requires about one-half pound of salt per kilograin of hardness removed.

Before regeneration the softener is backwashed with raw or soft water. Raw water may be used if it is not muddy. After backwashing, a stated quantity of saturated brine, mixed with a considerable quantity of diluting water, is passed through at a rate specified by the manufacturer. The time required for regeneration averages about half an hour.

The zeolite softener can handle muddy water if it is first passed through a sand filter. If the raw water is acid, the acid must be neutralized by soda ash or caustic soda before the water passes to the zeolite softener.

At high rating, boilers sometimes give trouble from



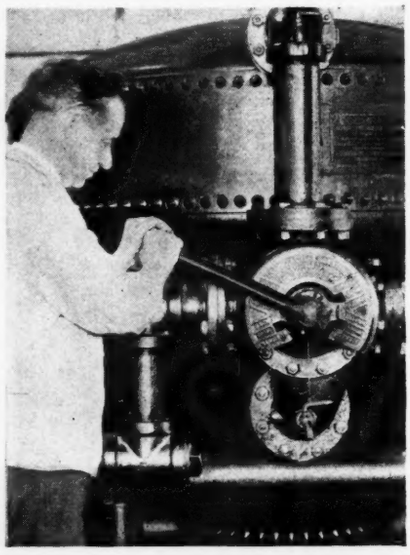
Double unit zeolite softener with valves for transferring flow. Brine tank at left

priming, which results in excessive moisture in the steam, sudden fall of superheat, deposits in superheaters and steam lines, etc. With higher concentrations of the boiler water these troubles are encountered at lower ratings. In practical operation it is necessary to find out by trial the maximum concentration that can be carried at the highest load to which the boiler is subjected. Concentration may be determined by the silver nitrate test, or by a hydrometer similar to that used to measure the density of the acid solution in storage batteries.

Blowdown Easily Determined

The amount of blowdown necessary to maintain any given concentration is easily figured when it is remembered that all solids entering the feed water must leave with the blowdown. If the blowdown is one-tenth of the feed, the concentration of the boiler water will be ten times that of the feed water. If the blowdown is one-hundredth of the feed, the boiler water concentration will be one hundred times that of the feed water. Only two things limit the blowdown. One is the cost of replacing the water. The other is the loss of the heat in the blowdown. The latter is the principal difficulty.

Equipment for continuous blowdown, which has been coming into general use in recent years, gives a better control of the amount of blowdown, and also makes practical the recovery of most of the blowdown heat. Such equipment combines one or more tubular heat exchangers with a rate controller permitting of a continuous and uniform escape of water from the boiler.



In order that the heat recovered in the heat exchanger be a net gain it must not replace any available heat from exhaust steam. If all of the heat delivered to the heat exchanger enters the feed water before the water passes to the heater, there may, in many cases, be such an excess.

To avoid this loss, the heat exchanger may be placed on the delivery side of the feed heater, or may be replaced by two units placed on both sides. The rate of blowdown is adjusted to maintain a definite concentration. The concentration test may be made with a hydrometer. One form of concentration hydrometer on the market contains a thermometer scale calibrated for direct correction of the hydrometer reading, thus making it unnecessary to wait for the blowdown samples to cool or to consult temperature correction tables.

Operation consists chiefly in testing the blowoff from the various boilers for concentration and adjusting the rate controller to increase or decrease the blow-off, as necessary.

Even more important than the maintenance of concentration is the complete elimination of oil and suspended matter.

Embrittlement of Boilers

In recent years there has been much discussion of the so-called caustic embrittlement of boilers. This has never occurred except where the waters contained a substantial amount of sodium carbonate and where the ratio of sodium sulphate to alkalinity expressed as sodium carbonate was below a certain value. The embrittlement cracking has always occurred around riveted joints.

It appears that at boiler pressures sodium carbonate decomposes to some extent into sodium hydrate. The higher the pressure the greater is the percentage so transformed.

Where the boiler seams are not inside-calked the solution may work into the riveted joints and concentrate, eventually weakening the metal with intercrystalline cracks. However, if sodium sulphate is present in sufficient quantities it will prevent this injurious action.

A.S.M.E. Code Requirements

The Boiler Code Committee of the A.S.M.E. prescribes a ratio of one part of sodium sulphate to one of total alkalinity (measured as sodium carbonate) for boiler pressure up to 150 lb. For pressures of 150 to 250 lb. a ratio of two is prescribed, and over 250 lb. a ratio of three to one. These ratios insure against embrittlement, according to recorded experience. It appears, however, that the requirements are too severe for higher pressures, and modifications may be expected.

If, with a hot-process softener, the sodium sulphate content of the water is not sufficient, sulphate may be added in the form of Glaubers salt introduced into the chemical feeding tank. For the determination of sulphate various test instruments are on the market, most of which depend upon visibility of an electric filament seen through turbid precipitate in the water after adding barium chloride and hydrochloric acid.

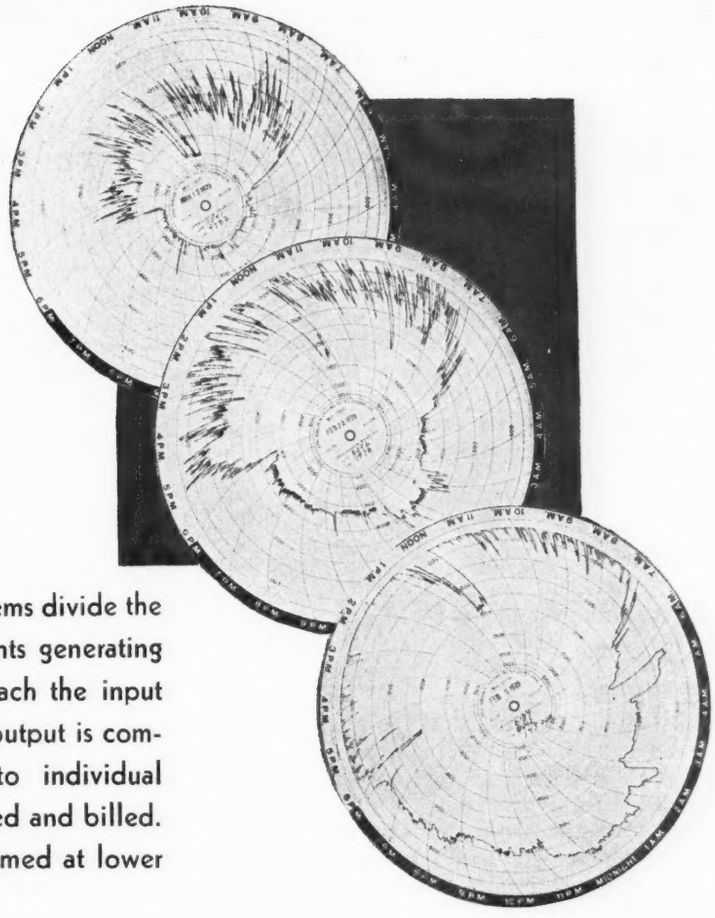
Zeolite treatment of water high in temporary hardness produces a correspondingly high content of sodium carbonate, sometimes requiring the addition of sulphate or sulphuric acid to maintain the "sulphate-carbonate ratio." Automatic devices for this acid feed are available.

Where hot-process treatment is employed there is a growing tendency to use one of the phosphates of sodium for after treatment at higher pressures than 250 lb. While the phosphate is too expensive for use as a chemical to precipitate all the hardness, it has the great advantage, for after treatment, that it is not affected by the temperature in high-pressure boilers. Phosphate may be introduced directly into the boiler or through the economizer. The latter should, in general, be avoided, as the economizer may scale.

Phosphate Replaces Carbonate

In high-pressure boilers, from 80 to 90 per cent of the sodium carbonate is transformed to caustic soda, which has no value in preventing scale, but requires a great amount of sodium sulphate to avoid caustic embrittlement. When used in connection with lime-soda treatment, the phosphate is used to complete the precipitation of hardness, thus rendering unnecessary a great excess of sodium carbonate, which in turn would require an excessive amount of sulphate to maintain the required ratio of sulphate to carbonate.

Records Turn Meter Readings Into Profits



The most effective power-record systems divide the power plant into a series of sub-plants generating the individual power services. For each the input and output are metered and cost of output is computed. Power services delivered to individual manufacturing departments are metered and billed. Net result: Fewer service units consumed at lower cost per unit

FROM long experience, much study and discussion, certain fundamentals of power record-keeping and their application have taken form. This article outlines the essentials of good practice as generally agreed upon today.

The primary purpose of power record-keeping is to lower costs. The secondary purpose (but of primary interest to parties concerned) is to permit of proper recognition of accomplishments. Both are of definite interest to the operator. He seeks the best possible dollar-performance of his plant, and he seeks the recognition that comes from the clearest possible measure of that performance.

Performance is best recorded in terms of input and output. Considering the power plant as a unit, its output is high-pressure steam, low-pressure steam, electricity, refrigeration, hot water, compressed air, etc. Other power services occasionally to be considered are cold water (where pumped or treated), ice, locally produced gas, etc.

Again considering the power plant as a single unit, the primary metering equipment required is that used to measure the physical input and output. Output steam, electricity and hot water should be metered. Refrigeration can be metered in terms of ammonia (with initial and expanded pressures) or brine (with the temperature difference between utgoing lines and return.) Compressed air and pumped water likewise can be metered without difficulty.

On the input side, coal should be measured as used, by automatic scales, weigh larries, or other means, and checked from time to time by actual measured inventories of coal piles and bunkers. Fuel oil, too, should be metered and checked at intervals by tank measurements.

In metering coal and fuel oil it is well to use correction factors to bring the measured consumption into agreement with purchased weights and volumes, since these are the ultimate accounting records.

The plant outputs of steam, electricity, refrigeration, etc., should be metered as a whole. In addition, the totals should be split through departmental meters, indicating separately the amount used by each important department.

Departmental Meters Most Important

It may be said that the engineer is not responsible for the consumption of services by departments. The fact remains that he, more than anybody else, is interested in these services. By metering consuming departments he creates a real incentive to saving which tends to reduce greatly the final bill and the total cost of the power services.

If the fuel consumption rises because of increased consumption of any power service, he is able to put his finger on the department causing the rise. The manager of that department may then explain whether the increased consumption is caused by waste, or by increased manufacturing production.

Departmental meters are given first place because experience has shown them to be the most important of all in their money-saving potentialities. When such meters have been installed it is a simple step to prepare actual departmental charges for services used. In fact,

it is well to set the power plant up as a separate "factory" producing and selling services to the manufacturing departments.

One firm has gone so far in this direction as to require payment of its bills by actual checks from the departments. While, in a sense, this is a mere bookkeeping transaction, the payment by actual check sets up the power plant as a producer of services, which should produce at the lowest cost, and the manufacturing department as a purchaser, which should economize in use.

The meters so far discussed are those required to measure the input and output of the power plant as a whole, and the power-service distribution to manufacturing departments. They are sufficient to show whether the power plant as a whole is doing a good job. But experience has shown that further meters must be supplied to show where leaks occur that may affect the total performance.

For this purpose the power plant should be split up into a group of sub-plants, such as the following: boiler plant, engine or turbine plant, diesel plant, hydro plant, compressor plant, refrigerating plant, pumping plant, etc. Each of these sub-plants is a distinct manufacturing unit, "selling" one or more power services and often "buying" other power services in addition to fuel, water, etc. For example, the engine plant "buys" steam and "sells" electricity plus exhaust steam. For each of these "plants" meters must be provided to measure input and output and the distribution of the output.

In the case of the boiler plant these will measure the input of fuel and water and the output of high-pressure steam. Submeters will split the outgoing steam into portions, one to process direct, one to engine plant, one to compressor plant, one to pumping plant, etc. The pumping plant, compressor plant or refrigerating plant may be diesel-driven, in which case the input of fuel oil must be separately metered.

Output of these plants must be measured—electricity from the engine plant, diesel plant and hydro plant, water from the pumping plant, compressed air from the compressor plant, etc.

Where some exhaust steam is delivered to process, this is part of the output of the engine plant, and should generally be metered.

In most cases it is sufficient to measure the input and output of each sub-plant. Sometimes, however, additional metering within the sub-plant is necessary to detect large potential losses. Boiler meters, feed-water meters, CO_2 recorders and other combustion equipment fall into this class.

Returning to the meter readings of sub-plant input and output, and of distribution, the record system built on this basis should, in general, deal with dollars as well as flow. Each sub-plant represents a certain investment, from which interest and depreciation can be computed. It carries certain direct charges for insurance, supervision and labor. Its share of certain general charges, such as insurance, taxes, etc., can be estimated. There remains the actual consumption of fuel, other raw materials, and of power service, all measured ultimately in dollars.

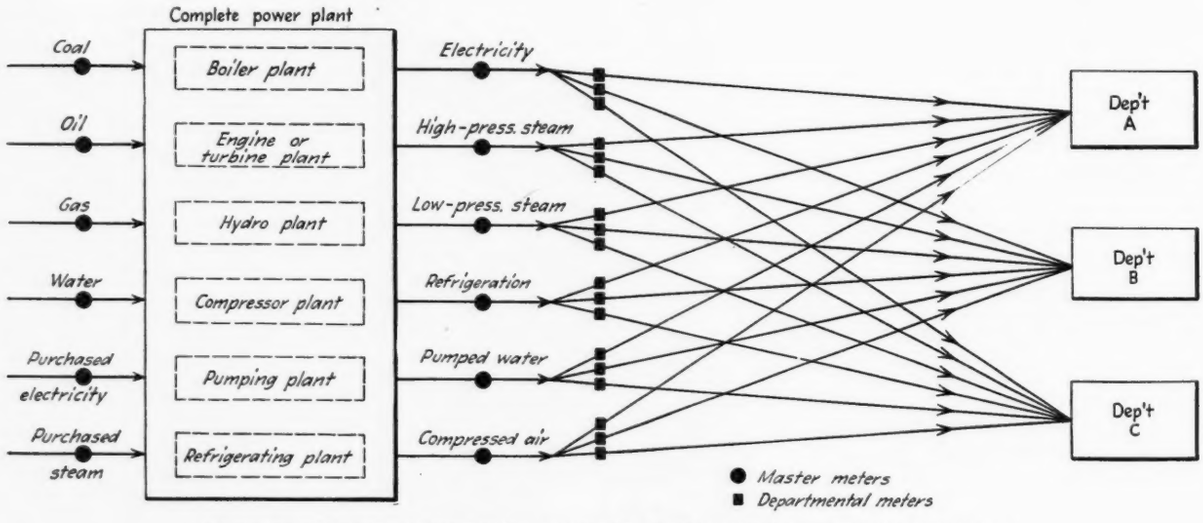
Start with the boiler room. To the cost of fuel, water, electricity, etc., add all other direct or indirect charges that apply to the boiler room. This gives the total cost of high-pressure steam. This total divided by the quantity gives the unit cost and the price at which it can be sold to other departments, including divisions of the power plant.

A large proportion of this steam is delivered to the engine (or turbine) room at this price. Add to its value other direct and indirect charges applicable to the engine room and the total is the cost of electricity produced. This total divided by the quantity gives the unit cost of electricity.

Some of this electricity is sold to factory departments at this rate. Another portion may be sold to the compressor plant. Add to its value the other direct and indirect charges applicable to the compressor plant and you have the total cost of the compressed air. When this is divided by the volume produced it gives the unit cost at which the compressed air can be billed to consuming department and to other sub-plants.

In similar fashion the cost of refrigeration, pumped water, etc., is figured.

One modification of this system adds a profit to all power-service costs before delivery to manufacturing divisions. This practice permits the power engineer to specify his price in advance, and gives the manufacturing departments a fixed basis to work on. It also provides



MASTER AND DEPARTMENTAL METERS REQUIRED IN A TYPICAL PLANT

Services charged through meters on right must equal (in dollars) the dollar value of everything delivered through entering master meters, plus all labor, supervision, insurance, supplies, repairs, interest and depreciation chargeable to power service. Connections and meters between sub-plants are omitted for the sake of simplicity.

for the engineer a special incentive to show the maximum profit by reducing his production cost well below his sales price.

Because of the great variety of instruments in use it would not be possible here to give detailed comments on their care. A few remarks will be of value: First, since instrument readings are an essential part of the accounting records, their proper keeping is a matter of vital importance. It is generally well to put one man in charge of all power instruments, and to make him responsible for their condition and accuracy and for proper entry of their readings. Often a young college graduate can be taught to handle this work. His training in computation will help him to keep the records in proper shape and make necessary computations.

Where submeters are used a totalizing meter should also be installed. This gives a constant check. Slight discrepancies will always exist, but can be averaged out

Boiler Room Record

Month of _____

Coal _____ tons @ $_____	$ _____	
Water _____ thous. cu.ft. @ $ _____	$ _____	
Electricity _____ kw.hr. @ $ _____	$ _____	
Labor	$ _____	
Repairs and maint.	$ _____	
Supplies	$ _____	
Supervision	$ _____	
Total Operating Cost	$ _____	$ _____
Interest _____ % of $_____	$ _____	
Depreciation _____ % of $_____	$ _____	
Taxes	$ _____	
Insurance	$ _____	
Other fixed charges	$ _____	
Total fixed charges	$ _____	$ _____
Total cost of steam		$ _____

Steam produced ____thous. lb.
Cost per thous. lb. $_____

Steam Billings

	Thous.Lb.	
To Engine Plant	_____	$ _____
To Compressor Plant	_____	$ _____
To Refrigerating Plant	_____	$ _____
To Dept. A	_____	$ _____
To Dept. B	_____	$ _____
To Dept. C	_____	$ _____

by the use of correction factors. Large variations call for inspection and checking of the individual meters. Where one man is responsible for the meters and the records it goes without saying that charts will be changed daily, pens kept clean and filled with ink, etc.

When departments are billed for their consumption of power services there is always the possibility that figures showing high consumption may be disputed. Where this possibility exists there is much to be said for the practice of calling in an outside testing organization to test all such meters yearly and to certify their accuracy.

Right at this point some reader may say "this is all very well, but my meter equipment is very incomplete and there is little chance of getting the necessary O.K. on a complete installation at the present time."

To such the answer must be that half a loaf is better than none. Even two meters, one showing total steam output, and the other electrical output, are of considerable value. Checked against the coal purchased, they give a means of determining the performance of the plant. They show clearly whether increased coal consumption is due to greater use or to inefficiency in production.

The installation of a few meters at strategic points will generally show such a substantial saving that approval for others may easily be obtained.

Care of Plant Piping

FROM the general condition of the power plant piping system one can form a fairly accurate opinion as to whether the plant is operated for best efficiency or is sadly neglected. In many cases it would seem that the engineer is entirely oblivious to the steam and water piping upon which the continuity of plant operation depends, or else has been unable to make the management "pipe-conscious" in order to secure funds for its maintenance.

But there are many less obvious parts of the piping system that may be in need of attention and whose maintenance is just as important to good operation as is the repair of such obvious wastes as leaking pipe joints and broken insulation. Traps, for example, are a part of the piping system that is frequently neglected, not only because steam leaking past the discharge valve is not visible, but also because traps are so frequently placed in such out-of-the-way places that their maintenance is a disagreeable job.

Quite frequently it is possible to tell whether a trap is leaking by feeling the discharge line, which, if warm, indicates the valve is tight, but if hot indicates leakage. More often, however, it is necessary to open the discharge piping and to make sure of the trap's condition, by observing whether steam blows through. Sometimes a plug or valve is provided for this purpose.

A cold discharge line should be looked upon with suspicion, because it may indicate that the trap is not functioning and that water, which should be drained, is being held up in the pipe. An investigation will quickly indicate whether the trap mechanism is binding or free and in proper working condition. If upon opening the trap it is found to be empty, although there is water to be drained, it is an indication that the trap is air-bound and that proper venting has not been provided.

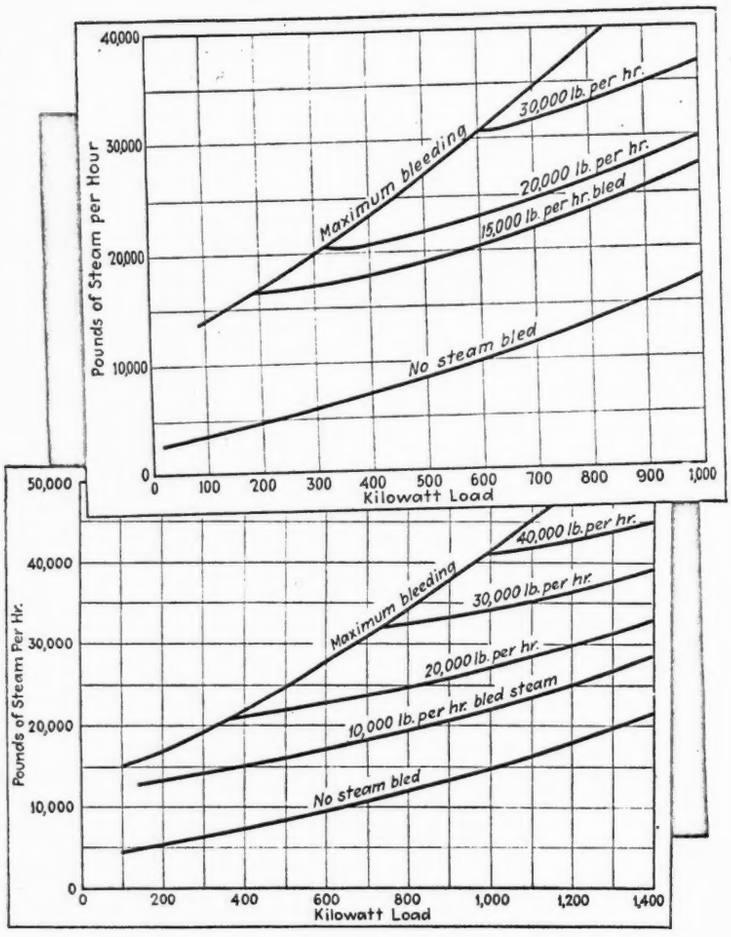
Traps should always be provided with means for inspection at regular intervals. Bypass valves should also be inspected, since just as much steam may be lost through them as through leaky trap valves.

Steam joints which persistently leak are often caused by the lack of flexibility in the piping system, and piping strains transmitted to engine or pump frames may cause vibration or bearing troubles. Thus, although provision for pipe expansion is a design problem, it is readily seen that its absence will be the cause of considerable trouble to the operating personnel.

Troubles from too stiff piping may be caused by the operator's failure to care for expansion joints. The sliding surfaces of slip-type joints should be kept clean and free from dirt and grit, which if allowed to accumulate may work in between the sliding parts and cause sticking. The sliding parts also require occasional lubrication. The packing should be kept tight enough to prevent leakage, and be renewed if it becomes hard.

Much of the work of maintaining pipe insulation in good repair may be eliminated if some consideration is given to protecting the insulation at points of recurring failure. Water-proofing of insulation where the pipe passes under open drains, valve stems that leak and other sources of water will probably pay for itself in reduced maintenance. Quite frequently it is necessary to step on parts of the piping to reach certain valves. At these points the pipe insulation is generally short-lived unless steel-jacketed or provided with other means of protection.

Figs. 1 and 2—Steam-consumption curves for Unit A, 1,000-kw. capacity, and Unit B, 1,400-kw. capacity



Industrial turbines are frequently required to meet special conditions and for this reason they are generally "tailor made" to fit each plant. Thus there are in operation bleeder turbines, back pressure turbines, mixed pressure units and various combinations of these with condensing units

Dividing Load BETWEEN INDUSTRIAL TURBINES

BECAUSE of the variety of types, no rule can be given concerning the division of load between various turbine units in an industrial plant except for the general statement that the loading should be such that a minimum of steam is lost to the condenser or atmosphere.

When back-pressure units operate in parallel with condensing units or with central station supply they should be so loaded that the demand for process steam is exactly satisfied, and at the same time the load should be divided between them so that the maximum of kilowatts is generated from the process steam. This then leaves a minimum load to be carried by the condensing unit or to be purchased.

If process-steam requirements are large in comparison with the electrical load, so that live steam must be supplied through a reducing valve, the way in which the electrical load is divided between the back-pressure units is of no importance. The load under these circumstances may be carried without loss of economy in any way that is convenient.

Condensing turbines from which steam is bled to process are generally provided with a bleeder control mechanism which will maintain practically constant pressure in the process steam lines over a wide range of power and steam load. The division of load between units of this character presents a two-fold problem: that of dividing the electrical load and that of dividing the process-steam load in such a way that both loads are satisfied with the least amount of steam flowing through the turbine throttles.

Bleeder mechanisms are generally set so that each unit automatically supplies process steam approximately in proportion to its kilowatt rating. Such division of the process-steam load is not, however, necessarily the most economical.

To arrive at the most economical division of the proces-steam load a schedule for the electrical load division between the various units must first be made. This can be compiled by the increment rate method based on the no-bleed steam consumption curve. With this electrical loading as a base the increment method can then be applied to determine the amount of steam to be bled from each unit in the manner indicated by the following example:

Figs. 1 and 2 are the steam-consumption curves for two bleeder-type condensing turbines of 1,000 and 1,400 kw. capacity each. The steam consumption for no-bleed operation and for several bleed loads are given. In Fig. 3 are the increment rate curves for both units. These have been obtained by drawing tangents to the steam-consumption curves and plotting the slope of the

tangent against the kilowatt load at the point of tangency. Another method of obtaining the increment-rate curve was published in *Power*, June 9, 1931, page 910. The most economical load exists when the increment rate is the same for each unit. Thus the loading schedule was made by first tabulating the load indicated by the non-bleed curves at increment rates of 10, 11, 12, etc., as in Table I. By plotting the data in this table against the sum of the loads carried on each unit the loading schedule curves of Fig. 4 were obtained. This loading applies when it is necessary to operate both units.

Thus with a plant load of 2,000 kw. Unit A should carry 750 kw. and Unit B 1,250 kw. This load division is indicated in Fig. 3 by the two heavy vertical lines. The most economical division of the process-steam load between the units at this plant kilowatt load exists at the intersection of an increment rate with the vertical load lines and the increment-rate curves of each machine. Thus at an increment rate of 16.6 there should be bled 15,000 lb. of steam from Unit A and about 11,000 lb. per hour from Unit B. Using this procedure for a number of different plant loads and increment rates, Table II may be compiled.

Examination of the data in the table quickly indicates it to be highly improbable that the bleeder mechanisms can be adjusted so that they will automatically divide the process-steam load to obtain best results. Of course this division of the process-steam load could be obtained by manual control, but generally this would be impracticable. The bleeder mechanism should therefore be set

TABLE I—TURBINE LOADING SCHEDULE

Increment rate.....	10	11	12	13	14	15	16	17	18	19	20	21
Load, Unit B, kw.....	200	270	340	410	480	550	630	700	770	840	915	990
Load, Unit A, kw.....	300	520	690	830	950	1060	1140	1210	1265	1300	1335	1370
Total plant load, kw..	500	790	1030	1240	1430	1610	1770	1910	2035	2140	2250	2360

TABLE II—DIVISION OF PROCESS STEAM

	—Kw. Load—		— Process-Steam Load—				
			— Unit A—		— Unit B—		
Plant load, Kw.	Unit A	Unit B	Lb. per Hr.	Per Cent	Lb. per Hr.	Per Cent	Total
1,000.....	330	670	15,000	40	22,500	60	37,500
			20,000	41	29,000	59	49,000
1,400.....	420	930	15,000	42	20,500	59	35,500
			20,000	45	24,000	55	44,000
1,800.....	645	1155	15,000	43	16,000	57	31,000
			20,000	50	20,000	50	40,000
			30,000	54	24,500	46	55,500
2,000.....	750	1250	15,000	57	11,000	43	26,000
			20,000	55	16,000	45	36,000
			30,000	58	21,500	41	51,500
2,200.....	880	1320	15,000	88	2,000	12	17,000
			20,000	71	8,000	29	28,000
			30,000	67	15,000	33	45,000

so that under average conditions the loading will closely follow that in Table II. If the average plant load during the time two units are in operation is 1,800 kw. it would seem that the bleeder mechanism of Unit A should be set to carry 50 to 55 per cent of the process load rather than 40 per cent, which would be the percentage indicated by the relative capacity of the two units.

With a plant load of 1,800 kw. and a process-steam load of 40,000 lb., the steam consumption, if loaded according to the schedules developed, would be 52,700 lb. per hour. If 40 per cent of the process steam were supplied from A and 60 per cent from B, instead of 50 per cent from each unit, the steam consumption would be 54,000 lb. per hour. Proper loading, therefore, would save 1,300 lb. of steam per hour.

To maintain such a loading schedule flow meters in the bleeder lines from each turbine become a necessary part of the plant equipment. Also, the turbine-governing mechanisms must have characteristics that permit parallel operation—any tendency of one unit to hog the load being a matter of governor design that should be remedied.

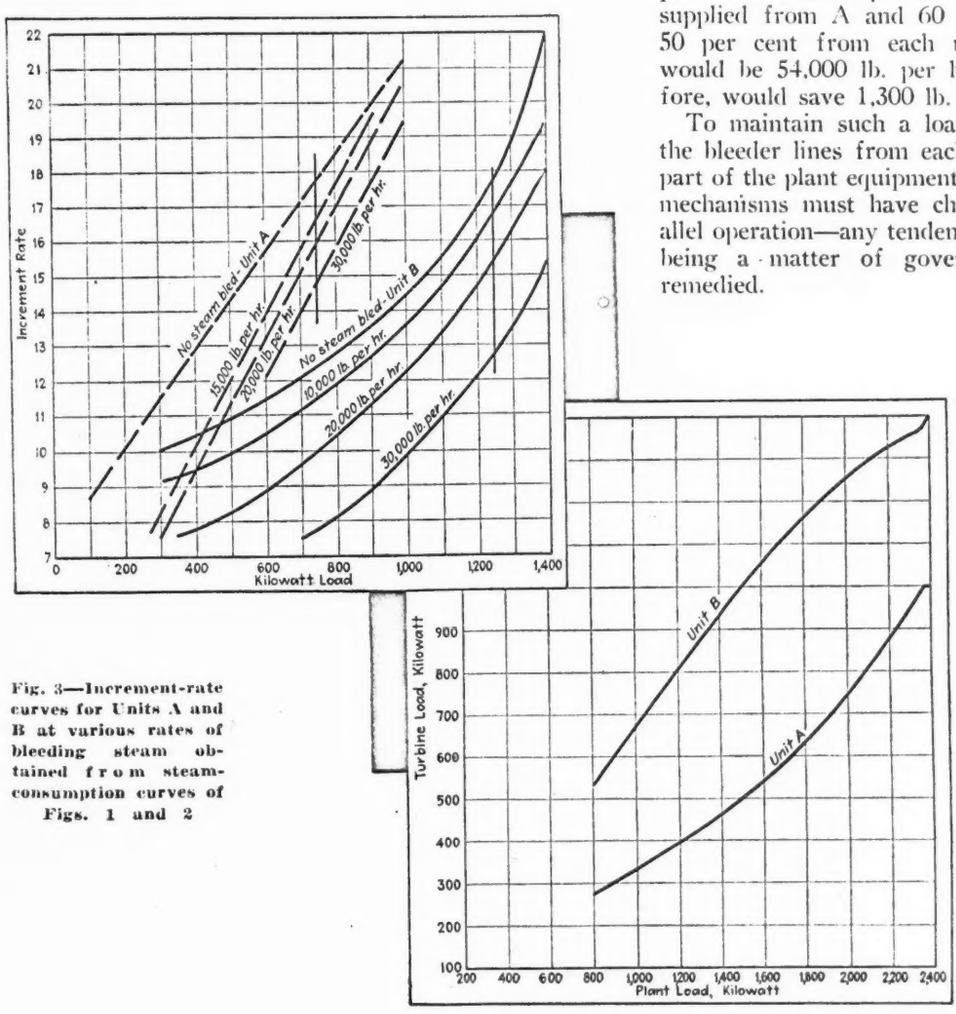

Increment Rate
Kilowatt Load
No steam bled - Unit A
15,000 lb. per hr.
20,000 lb. per hr.
30,000 lb. per hr.
No steam bled - Unit B
10,000 lb. per hr.
20,000 lb. per hr.
30,000 lb. per hr.

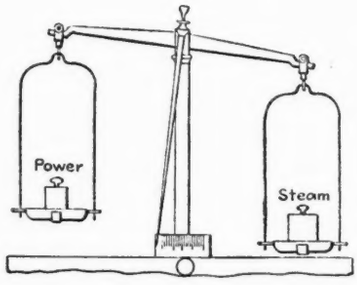
Fig. 3—Increment-rate curves for Units A and B at various rates of bleeding steam obtained from steam-consumption curves of Figs. 1 and 2

Fig. 4 — Economical division of electrical load between units for various plant loads plotted from turbine-loading schedule

"Don't Waste Exhaust Steam"

IS THE WHOLE STORY OF HEAT BALANCE

The fundamental principles of heat balance are so utterly simple that they are often overlooked. If an industrial plant throws to waste no exhaust steam and no hot water (circulating or otherwise) its heat balance is good



No Loss

AS THE term is used in this article, "heat balance" means a balance between the demand for exhaust steam for process and heating, and its "production" by engines and turbines. From much talk about maintaining heat balance some have gained the impression that it is desirable to keep the power and exhaust-steam demands as closely balanced as possible. This is not true in the typical industrial plant where there is no outlet for the sale of excess power.

Real Balance Not Needed

As far as saving fuel is concerned, the only heat balance that needs to be maintained is one in which the power load does not exceed the process and heating load. Because of this, what often seems to be a complex problem is really very simple. The operator need only remember that he should generate as much of his power demand as possible as a byproduct of his process and heating load; and also that no harm is done if the equipment installed can generate more byproduct power than the load demands.

This will be more clearly understood by an example. Consider two factories just alike. Suppose in each that the process steam demand is 10,000 lb. per hour of steam at 5 lb. gage pressure, this total including the steam needed to heat the feed water to 212 deg. F. Suppose, also, that each boiler plant generates 10,000 lb. per hour of steam at 200 lb. pressure and 100 deg. superheat.

Plant A has a back-pressure turbine consuming 25 lb. of steam per kilowatt-hour. That in Plant B takes 20 lb. per kilowatt-hour. In both plants the load is constant at 400 kw.

In Plant A the entire 10,000 lb. of steam must pass through the turbine to generate 400 kw. In Plant B the turbine will require only 8,000 lb. of steam. This will leave 2,000 lb. to pass through a reducing valve to give the process demand of 10,000 lb.

Unbalanced Plant Has Same Coal Bill

Both plants deliver 400 kw. and 10,000 lb. per hour of process steam. Both generate 10,000 lb. of high-pressure steam under the same conditions. Hence, both burn the same amount of coal, and the heat balance in one is as good as in the other.

Some reader may see an apparent flaw in this argument. He will point out that the 2,000 lb. of steam throttled in Plant B will have a high superheat, which will increase somewhat the heat in the whole 10,000 lb. of process steam.

This gain is an illusion, for the more efficient turbine of Plant B will remove more heat from each pound of steam, so its exhaust will have a lower quality than that of A. This will cancel the heat gain in the throttled steam. The entire 10,000 lb. will have substantially the same quality in both cases.

Plant With a Margin Is Better Off

Under the assumed conditions one plant is as good as the other. But this is not to say that in actual operation the plant designed to operate with an exact balance is as good as one with a margin on the power side. This margin is one of safety. Perhaps the power load may grow faster than the steam load, in which case Plant A will be unprotected and will have to exhaust steam to atmosphere with a resulting waste of fuel and difficulties due to increased feed-water make-up.

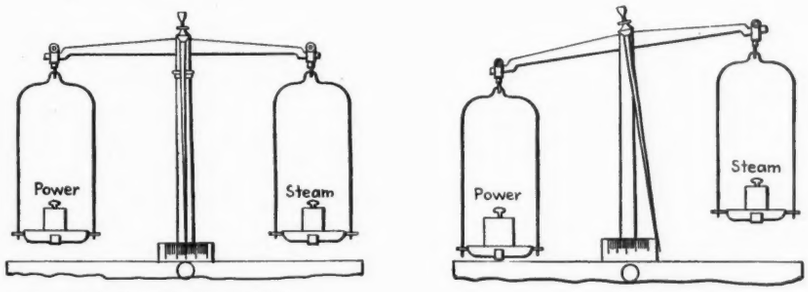
Practically, the heat-balance problem simmers down to this: *Design and operate the plant to keep to zero,*

if possible, or otherwise at a minimum, any waste of heat in atmospheric exhaust or in warm water.

If a plant has no condenser, and no steam blows to atmosphere, the heat balance is good, regardless of internal arrangements. Steam for process may be bled at any desired pressure, taken from exhaust or in part from the boiler through a reducing valve, or in all of these ways. Generating units may be efficient or inefficient. Evaporators may be used or not. Feed temperature may be high or low. Yet the heat balance will be perfect if no steam or hot water passes to waste from the power house. This applies to a condensing plant if all of the hot circulating water is consumed in process.

Draw A Circle Around the Plant

In short, draw a circle around the entire plant. The only real losses are those passing through the circle.



If the steam load exceeds the power load (left) part of the process steam comes through reducing valves. This condition is even more desirable than an exact balance (center), because there is less danger of slipping into the condition (right) where part of the power load must be generated from steam blown to atmosphere or condenser

These are flue loss, carbon loss in ash, radiation, steam and hot water. The lower their total the greater the efficiency of the plant. Only the latter two, however, come under the heading of heat balance.

Although this number of *Power* deals with operation, a word should be said about design, because the designer imposes definite limitations on the heat balance of the plant.

If the ratio of process steam to power is very high, as often happens, the heat-balance problem is extremely simple. Units of moderate efficiency bled to process, or exhausting to process, or both, will at all times produce the necessary power without condensing operation, or without blowing exhaust steam to the atmosphere. Such a plant will give a perfect heat balance.

If make-up is needed evaporators may be hooked up to receive steam at any pressure and to discharge vapor at any pressure, without waste. They will naturally, then, be bought to use a large temperature drop, and thus reduce their first cost.

Ways to Improve Heat Balance

However, the opposite condition is encountered in many plants, particularly in summer, when the steam load is low in comparison with the power. In such cases the designer should take several steps to improve the heat balance. First, he should consider the use of more efficient generating units. If this still leaves a margin of exhaust steam he should consider electrically driven auxiliaries, with or without steam-driven stand-by. If there is still an excess of exhaust steam the only cure is higher steam pressure or lower process pressure, both of which will increase the amount of power that can be extracted from a given flow of steam. The thing required is the maximum possible expansion of each portion of process steam through the most efficient power-generating unit.

This applies also where steam is bled at one or more pressures. The lower the pressure at which steam is bled the more power obtained from its expansion. Thus each of these bleeder pressures should be only a little above the corresponding process pressure. Any change that will shift steam demand to the exhaust from a bleeder point, or to a lower bleeder point, will increase the amount of power generated from the same steam supply.

After taking account of all helps possible it may still be necessary to waste some of the steam used in power generation.

Here consideration should be given to condensing operation. In a process plant condensing is always a waste, but it is a much smaller waste than blowing steam to atmosphere — the lesser of two evils. It will generally be advisable to operate condensing to the extent that this eliminates atmospheric exhaust.

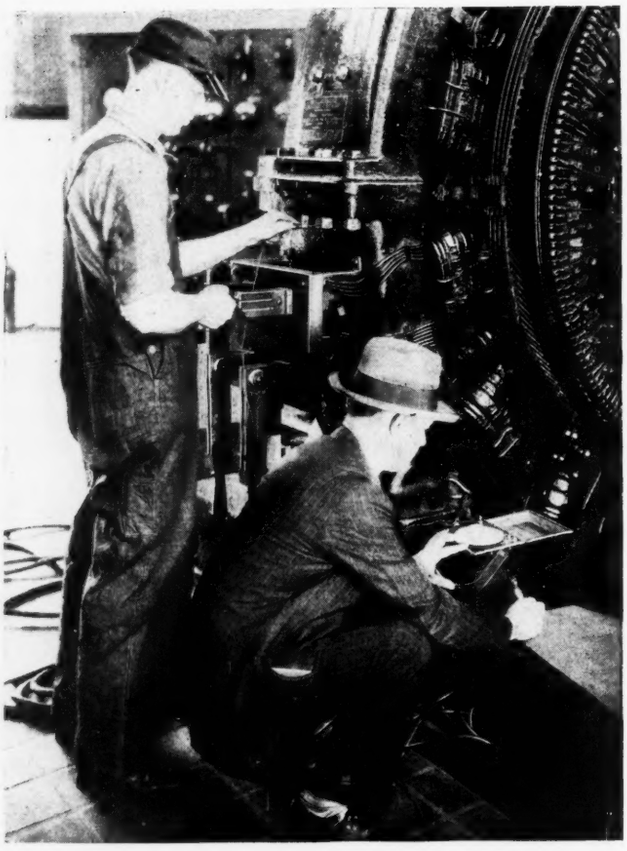
One thing to avoid particularly in operation, however, is loading up the condensing unit to the point where the available bled and exhaust steam are not equal to process demands, so that reducing valves from the boiler open.

This calls for further comment. The existence of a condensing unit changes the heat balance rule already given. It was stated that it is not necessary to maintain a balance so long as the power load is less than the steam load. In non-condensing plants the opening of reducing valves to supplement the steam produced by exhaust and bled points represents no loss. But in the plant with a condensing unit, economy requires that an exact balance be maintained, that is, that the power generated by the condensing unit be just equal to the difference between the load and the total that can be generated as a byproduct from the process steam. In the case of a bleeder condensing turbine, of course, this balance takes care of itself.

Cutting Down the Exhaust Loss

The extent of the loss from atmospheric exhaust is often not fully realized. Power generated as a by-product represents not more than one-half pound of coal per kilowatt-hour, regardless of the efficiency of the unit. Power generated from steam later blown to waste at atmospheric pressure will generally represent at least 3 lb. of coal per kilowatt-hour, and often more. Thus the fuel cost of such power is six times that of power generated as a byproduct, an increase of 500 per cent.

When the atmospheric exhaust is blowing, or in danger of blowing, everything possible should be done to reduce the production of steam. The first step, obviously, is to reduce the consumption of power. Generally, some of the power production of the plant is used in services to some extent under the control of the power engineer. It may be possible to shift some of this load to periods when the ratio of steam to power demand is higher. Where electrically driven auxiliaries are available, along with less-efficient steam-driven auxiliaries, the latter should be shut down whenever possible and replaced by the former, which will reduce plant steam consumption.



Insulation resistance should be checked periodically so that defects will be detected before they cause a shutdown

Practices That Improve The Operation of Electrical Equipment

Modern operating practices that have been adopted to meet the requirements for a higher degree of reliability and the demands for more exact knowledge of equipment performance

SIMPLICITY in operation is an outstanding feature of modern electrical equipment. In the operation of the older types of electrical apparatus much was left to the judgment and skill of the operator, whereas present practice reduces operation to pushing a button, after which the functions of starting, manipulating and stopping are done automatically. In many cases the operator is eliminated entirely and operations are performed automatically according to demand in the power or other system.

Substations are, in general, made automatic, or several are controlled from a central point by supervisory control. Many hydro-electric plants have been made automatic, even with an operator in the plant many of the operating functions are performed automatically. Frequency control and voltage regulation on large systems are now taken care of by automatic devices.

With these changes in operating practice, and the demands for more reliable service, the necessity for better maintenance, for more complete knowledge of equipment performance and conditions under which it operates have increased immensely. This means closer attention to the causes of trouble and their elimination before a failure occurs; also a greater use of meters.

Present-day ideas on the operation of electrical equipment accept the theory that most causes of trouble can be found and corrected before they result in failure at an inopportune time. Careful application of this principle will keep down repair costs, increase equipment reliability, reduce power consumption and increase production with a decreased unit cost.

How effective this method can be in preventing failures is indicated by the experience in one large plant with a 10,000-hp. connected load of motors operating under very wet conditions. In three years a short-circuit has not occurred in any conduit line, and the cost of labor in the electrical department has been reduced about $7,000 per year. The cost of repairs has also been substantially decreased below that which obtained before the present program was put into effect. All this was accomplished under conditions of increased production and load, which adds to the significance of the practice followed.

Preventing oil getting out of the bearings onto the windings and insulation of electrical machines is one of the first essentials in a good operating program. Oil not only assists dust and other dirt to adhere to the windings and other parts, but it is also detrimental to insulation. Oil is penetrating and will work into small cracks in the insulation and carry small particles of conducting materials with it. This will cause a leakage path for current to ground that will eventually cause a breakdown.

When anti-friction bearings are used on electrical equipment they are generally constructed to keep the oil in the bearings and the dirt out. Modern sleeve-type bearings are designed in the same way, so that if the right type of lubricant is used and properly applied little trouble should be experienced with the oil getting in the windings and other insulated parts of the machines. Many of the older types of machines are equipped with open sleeve bearings. The rings churn the oil in the

bearings into a vapor and the ventilating air carries it into the machine. This difficulty can be largely alleviated by closing the bearings with felt washers, keeping the bearings clean and maintaining the oil at the correct level.

For cleaning dust and dirt out of windings compressed air at a pressure about 75 lb. per square inch is used extensively. This may be supplied from a stationary compressor with pipes running to each machine, or a portable compressor may be used. For ordinary cleaning a small motor-driven hand blower may be used. It is common practice to use the blower as a vacuum cleaner, and instead of blowing the dust off the machine it is delivered into a container. Stationary vacuum-cleaning installations are being made for cleaning plant equipment. There is much to be said in favor of this practice.

The commutator and slip rings on electric machines have always been a vulnerable spot, and a wide variety of tools have been developed for servicing this part of the equipment. High mica, a common ailment of commutators, has been largely eliminated by undercutting. Many types of tools are available for doing this work, ranging from a simple hand device to a power-driven machine. Undercutting the mica should not be considered a panacea for all commutator ills, particularly if the slots are left open. Where the air is laden with conducting vapors or dusts, leaving the mica flush and carefully grinding the commutator at intervals to maintain a true surface may prove to be the best practice. Using brushes that are slightly abrasive may also be advisable.

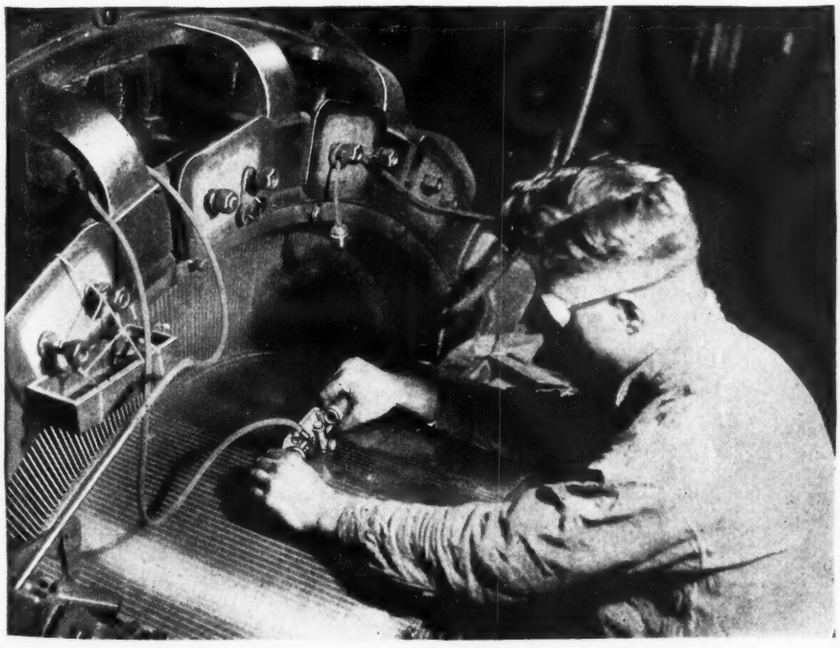
Modern brushes are a highly developed product compared to what they were several years ago, and manufacturers are in a position to supply a grade suited to almost any combination of operating conditions. If there is something fundamentally wrong with a machine or the conditions under which it operates the brushes cannot be expected to cure the trouble no matter how superior their quality. Brush manufacturers have engineers who are specialists in the application of their product, and when operators are having difficulties with brushes they can do no better than to call on a brush engineer for assistance to help get at the source of the trouble.

Truing commutators with a handstone has eliminated many of the ills caused by sandpaper. A stone not only gives a much smoother surface, but it tends to maintain the commutator in a true circle. When a commutator or slip ring requires treatment that cannot be applied by a handstone, grinding in place with a stone held in an adjustable rest or with a revolving wheel gives a better job than can be obtained by the older practice of using a lathe tool and sandpaper. Handstones and grinding devices held in a rest have been developed in forms for use on practically every design of machine.

Spiral Grooves in Commutators

Cutting a spiral groove in commutators and slip rings gives promise of improved operation. After the commutator on a 1,000-kw., 500-volt generator that could not be made to operate satisfactorily, had a $\frac{3}{8}$-in. pitch, $\frac{1}{8}$-in. spiral groove cut in its surface the machine carried full load without any glowing at the brushes and the commutator ran 10 deg. cooler than before grooving. Previous to grooving, the commutator and brushes would develop trouble in a few hours if operated at full load. Grooving of slip rings has also proved highly satisfactory. This practice is undoubtedly not a remedy for all commutator ills, but it provides the operator with another tool for meeting certain difficulties.

The practice of grooving commutators and slip rings is based on the idea that even a well-fitted brush riding on a smooth ring makes contact at comparatively few, minute points. On a continuous surface these points carry all the current. They tend to heat and expand, and slightly lift the brush, thus preventing uniform distribution of the current in it. Heating of the contact points on the brushes' faces reduces their resistance causing them to take an increased current and still further aggravate conditions. By cutting a spiral groove in the slip ring or commutator, the surface under the brush is not continuous and new points on the brush's surface are continually being brought into contact. Even if the projected area of the commutator or slip ring in contact with the brush has been reduced by the grooves, the actual area is more effectively used and the current more uniformly distributed in the brush, thus improving operation.



Undercutting the commutator mica prevents much of the brush trouble that used to occur with flush mica

Although the actual handling of power-generating and power-application equipment is now more simple than ever before, more complete knowledge of what is going on in the system is required. This means a greater use of meters to obtain records of insulation resistance, equipment temperatures, transient conditions, volts, amperes, power, frequency and many other factors. Not very long ago the oscillograph was considered a laboratory instrument only. This device has now been developed to where it can be mounted on a switchboard and arranged to start automatically and record any

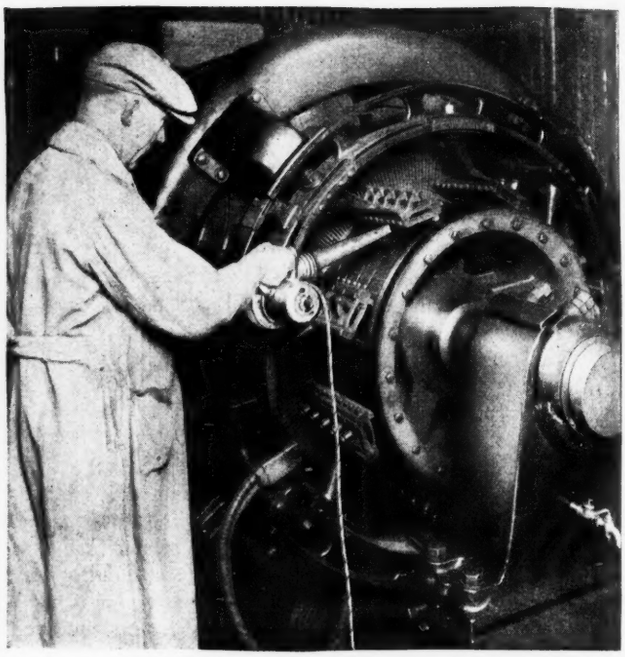
disturbance on the system that cannot be recorded by the ordinary type of instrument. In this way a check is obtained on the rupturing duty of circuit breakers, the speed of relays and other operating features and is thereby the means of detecting and correcting any difficulties which may develop.

A great deal of attention is now being given to the insulation resistance of electrical equipment as a means of detecting weak spots before they develop into serious trouble causing costly and unexpected shutdown and expensive repair bills. Although insulation resistance measurements do not tell the whole story of the quality of insulation, they are, when made periodically, about the best and most practical check so far devised. High-voltage tests have a place in checking the condition of new equipment, but they should not be generally applied to apparatus that has been in service for some time. Even though the test may not break down the insulation, it may be injured so that a failure will occur later.

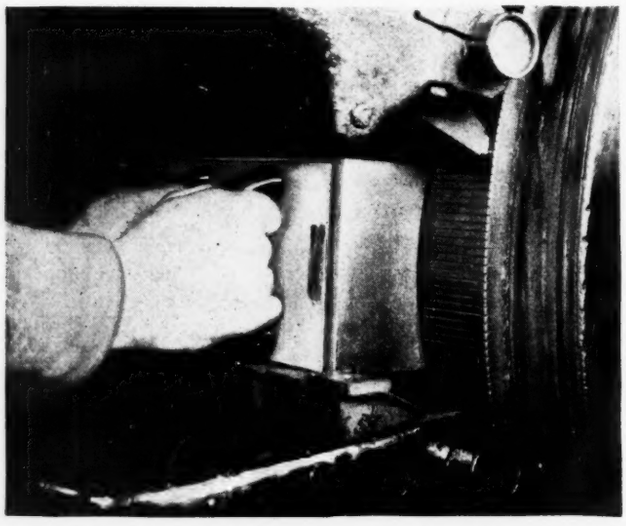
For measuring insulation resistance, the megohm meter, of which there are several types available, has come into general use. Periodic tests are made on the different pieces of equipment in the plant and a record kept of these readings. Comparison of these periodic readings will show if the insulation is deteriorating to where it may be unsafe. Before this condition is reached the cause can be located and corrected, instead of letting the machine run until a breakdown occurs.

In one large plant, insulation tests are made of all equipment during the regular monthly inspections. Effort is made to maintain the insulation resistance of all 440-volt equipment above 5 megohms and on 250-volt equipment above 2 megohms. When the insulation resistance drops below these values on any motor, it is disconnected at the first opportunity and the wiring, control apparatus, and the machine are tested separately to find the fault. If the wiring has the low insulation resistance, the conductors are pulled out of the conduit and replaced. When the fault is in the motor or control these are thoroughly cleaned and dried, to restore the insulation resistance, and given a coat of insulation varnish. This practice has been successful in reducing unexpected shutdowns.

Periodically drying out the windings and giving them a coat of insulating varnish is becoming general practice. It is common to dismantle small machines and, after heating, dip them into baking varnish and again bake the windings. When dipping facilities are not available the varnish may be sprayed on the windings. On large machines, drying varnish is applied to the windings by spraying. The period between giving the windings an application of insulating compound will vary with conditions. Where operation is severe, as in some plants, the motors are treated every six months. In one large plant with unusually difficult operating conditions seven armature winders were kept busy rewinding motors that failed. A semi-annual cleaning of the motors and treating the windings with insulating compound practically eliminated motor failures and the cost of maintenance was greatly reduced. In plants where the conditions are less severe one- to three-year periods between a thorough cleaning and treating of the winding with insulating compound has been found to be sufficient. In a large ice plant every piece of equipment in the plant is given a thorough overhauling and put into good condition each winter when business is slack. An electrical failure in this plant is practically unknown.



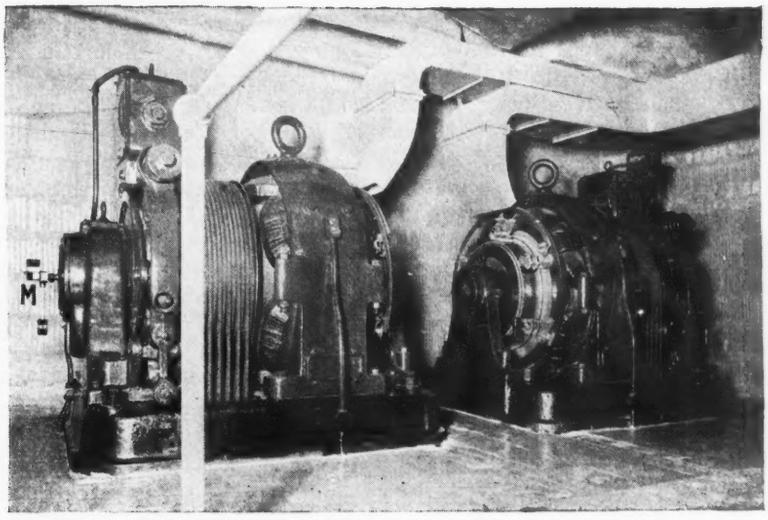
Electrically driven small portable blowers are used extensively for equipment cleaning



Judicious handstoning of commutators and slip rings will eliminate the necessity for many large truing jobs

The condition of oil in transformers and switching equipment is being given more careful attention than ever before. The period between tests on the oil varies with conditions. In one plant using water-cooled transformers a sample of oil is drawn weekly from the bottom of each transformer. If it shows signs of moisture a breakdown test is made on the sample. A breakdown test is made at least once a year even if the oil does not show signs of moisture. The practice is to maintain the oil in condition where it will stand 22,000 volts across a $\frac{1}{10}$-in. gap between one-inch disks.

Meters of both the stationary and portable types are being employed extensively to obtain load and other records of plant operation, and their use is rapidly increasing. In well-operated plants power is metered to each department, and frequently each important machine or group of machines is metered and daily readings taken. These meter readings not only serve a valuable purpose in production, but also in showing up faults.



These elevator motors are forced ventilated with filtered air and have car-milage recorders, one being shown at *M*

Elevator Operation IN MODERN BUILDINGS

Elevator operation in large buildings offers many opportunities for power saving, reducing maintenance costs, increasing reliability and improving service to the building tenants, as here suggested

IN LARGE, modern office and other types of buildings, the elevators are such a large item of operating cost as to merit careful attention. When elevators are of the car-switch-controlled type, power consumption can be increased materially by a poor operator on the car making false stops. A study of records of power consumption compared with the number of stops per car-mile of two elevators in similar service will show a power increase as the number of stops per car-mile increases.

In some buildings a watt-hour meter, a mileage recorder and a stop counter are installed on each elevator and are read daily. From these readings a record form is filled out showing when each elevator went into service and when it was taken out, the total power consumption, car-miles and number of stops for each car, the stops per trip and the stops per car-mile, and the power consumption per car-mile. The records are watched; and if the power consumption becomes high on any car, the cause is ascertained and removed. The efficiency of operators in some buildings is judged by the stops per car-mile for a given class of service. If new operators cannot attain a certain excellence of service in a given time they are dismissed.

Where power consumption is consistently high on a car with the normal number of stops per car-mile it is an indication of excessive friction in the moving parts, such as might be caused by improper lubrication of guide rails or machine bearings, or because of parts being out of line. Knowing that such conditions exist, those responsible for the equipment are in a position to search out the fault and remove the cause.

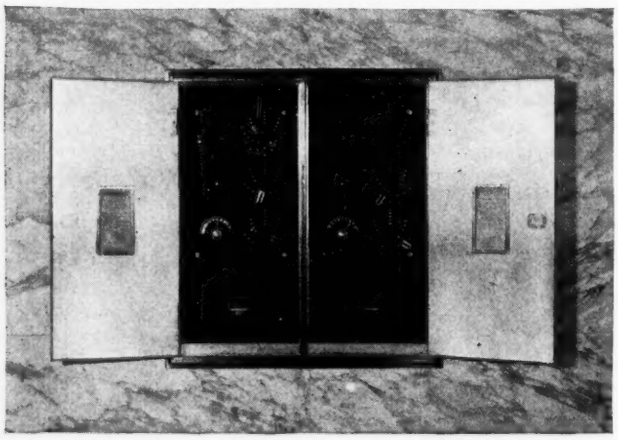
Automatic-landing type elevators, when properly adjusted, stop level with the floors without leveling; consequently there is no adjusting the car to the floor because of faulty stops. For this reason, power consumption for elevators of this type in a given service is more consistent than with car-switch-controlled machines. There are opportunities for excessive power consumption with this equipment, such as allowing the motor-generator to run when the car is out of service, and excessive friction of parts due to lack of lubrication. On each machine, a watt-hour meter, a stop counter and a mileage recorder from which proper records are worked up and compared daily will give valuable information on equipment operation and the traffic handled. Automatic leveling elevators can be out of adjustment and still stop level with the landing. This, however, will require unnecessary operation of the leveling equipment and will have practically the same effect on power consumption as an operator making false stops with car-switch control. False stops at the floors not only increase the power consumption and wear of the control equipment, but also decrease the life of the hoisting

rope. The latter is also a good reason for keeping a check on the stops made by a car.

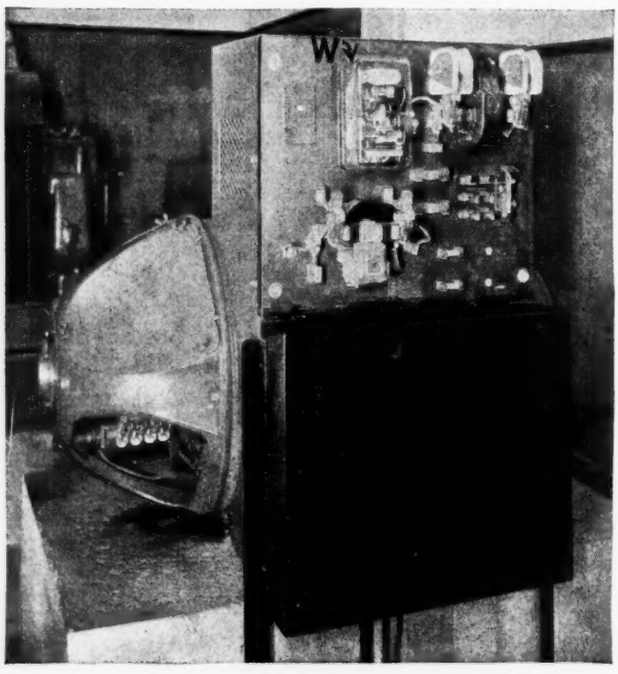
Elevator rope life is being studied more carefully today than ever before. To this end greater use is being made of mileage recorders. Without proper records of rope mileage, stops per car mile and other pertinent information on elevator operation, any attempt to appraise rope life is very much of a guess.

On most traction-type passenger elevators there are six ropes, with their ends attached to the cars crosshead and to the counterweight. Unequal stretch in these ropes, unequal tread diameter of sheave grooves and other factors make it almost impossible to keep the ropes equally loaded. On high-rise cars a small difference in tread diameter of the sheave grooves may throw practically all the load on part of the ropes and in addition cause them to slip in the grooves. To compensate for factors that tend to load ropes unequally, automatic equalizers are used extensively.

Until recent years ropes of the 6x19 construction was generally used on elevators. The wires in this type are, apparently, too large, as the ropes usually had to be replaced because of broken wires, not wear. The present tendency is toward the use of the more flexible 8x19 construction. Records of rope life of this type indicate improved performance.



Automatic scheduling equipments are used to dispatch the cars from the bottom and top landings



The watt-hour meter *W* is on the motor driving the generator that supplies power to the elevator motor

Many of the tools that have been developed for maintaining electrical equipment find a place in a modern elevator room. Commutator undercutting devices, handstones, portable blowers and other devices mentioned in the article on electrical operation find a place in good elevator operating practice. In some installations compressed air is piped to each elevator machine for use in cleaning the equipment. The use of megohm meters to check the insulation and its periodic treatment with insulating compounds have been adopted in the electric equipment maintenance. Modern elevator rooms are as conspicuous examples of cleanliness and proper upkeep as their predecessors were dirty.

Several installations of forced ventilation have been made in elevator rooms. One system takes the air in through a filter to fans from where it is piped to each motor and generator. The air is blown from nozzles directly into the machines. In this way clean air at outside temperature is delivered into the equipment. The temperature of the machines is much lower than if their ventilating air were taken from the room. Filtering the air keeps a large part of the dirt out of the windings. There is much to be said in favor of forced ventilation of elevator rooms. A thorough study of the problem in relation to the equipment design and operation may show that it has greater economic possibilities than now apparent.

Maintaining Regular Schedules

Much attention is being given to the problem of the operation of the cars to expedite handling of passengers. Traffic studies are made on which to base schedules. No standard basis has been established for elevator service quality. It varies for the number of cars in operation. One authority considers the service excellent when the interval is 18 sec. between cars leaving the first floor with eight cars in a bank, and 30 sec. interval between car with four cars in a bank. The service is classed as fair when the interval between cars is 24 sec. with eight cars in a bank and 40 sec. with four cars. This takes into consideration the round-trip time, which is a measure of the average time required for passengers to reach their floors after entering the building.

Maintaining regular intervals between cars gives the shortest average passenger waiting time, unless abnormal traffic conditions develop. To keep the cars operating with proper time interval between them, automatic scheduling equipments are coming into wide use. These signal the operators when to leave the first floor, when to leave the top floor and when the cars should be half way down the hoistway. This system not only releaves the dispatcher of signaling the cars to leave the first floor, but also assists the operators to run the cars on schedule. Studies have shown that, without automatic scheduling, even when the cars leave the first floor at regular intervals the time between them will vary widely at the intermediate floors

Although automatic scheduling of the cars improves the service it does not insure that the cars will always run on schedule. The number of calls in a given period may vary widely. One car may have calls on each floor when the following car has none. For this reason the dispatcher is provided with a floor-call and a car-position indicator. When the dispatcher sees that a car is falling behind its schedule some of it calls are bypassed to the following car and in this way the schedule is maintained.

Oil Engine Operation Depends Upon The Governor

By H. F. SHEPHERD

Fig. 1—One type of governor employed on air-injection engines

The governor action of an airless-injection diesel should fulfill the following requirements:

Drop of speed when full load is slowly built up from friction load should not be more than 4 to 5 per cent.

Drop of speed when full load is applied instantly or rise of speed when full load is thrown off instantly, should not be more than 15 per cent.

The governor should settle to its operating position after instant loading or unloading with not more than three "swings" or oscillations.

The variation from the normal speed at any fixed load should not exceed 1 per cent.

The governor should not hunt under any condition.

If the mechanism is deliberately forced out of its operating position with the engine running the governor should assume control immediately on its release.

WITH the development of the airless-injection (or solid-injection) diesel greater attention has been given to the design of the governor, which must function properly if the engine speed variations are not to be excessive. In fact, this governor must be far more stable than that of an air-injection engine, where the pump delivers the fuel charge to the cylinder in two strokes, thus permitting the governor to control the fuel feed during each revolution. In the four-stroke-cycle airless-injection engine the entire fuel charge, of course, is delivered during a short portion of one piston stroke. The governor has no influence upon the engine's speed until the piston has completed the four strokes of the cycle. The necessity for a close regulating governor is obvious.

The governors of engines working on the commonrail system are almost invariably of the plain centrifugal type operating on a set of spray lifting wedges connected by levers to a "wedge shaft" which the governor rotates, as shown at *A*, Fig. 5. When the wedge is fully in between the mechanism operated by the spray cam and that which lifts the spray their motions are equal, less a small clearance. If the wedge is withdrawn fully, as in instant unloading of the engine, the spray cam operates a portion of the mechanism as usual, but the spray needle valve is not opened, there being too much lost motion introduced by the governor action.

On adjusting the linkage between the governor and wedge shaft it is always best to release the governor spring and to make certain that there is free travel of the governor and its attached mechanism sufficient to insert and withdraw the wedge completely. Once this adjustment is made with the engine standing it should never be disturbed while the engine is running. All speed adjustments should be made at the governor spring, unless, as is unlikely, a special form of governor known as the "power governor" is used with fixed spring and variable hand linkage adjustment. This causes the governor, which has a great excess of travel, to pick up the control machanism at some definite part of the lift.

Taking the regulation requirements in order, speed variation comes under observation first. It is not unusual to find a good governor connected to a good control device without resulting good regulation. The cause of dissatisfaction is simple. To control the engine a certain definite wedge movement is required to change from full-load spray lift and timing to that automatic adjustment required for friction load. To produce this movement a definite movement of the governor sleeve is called for, as wedge and governor sleeve are rigidly connected by links and levers. To cause this change of governor sleeve position a change of governor speed is required, together with the increase of radius due to the movement of the governor weights outward. If the governor spring is so stiff that a 4 to 5 per cent speed change is unable to produce enough increase of centrifugal force to make the sleeve assume the required position, the speed will simply increase until the engine is under control at some other and higher speed.

The first and simplest way to overcome this undesirable condition is by changing the lever ratio between

governor and wedge. If the speed variation from no load to full load is excessive the lever arm should be lengthened by sliding the connection away from the governor rocker shaft. By this means the governor is enabled to effect the full wedge movement by a shorter movement of its weights and sleeve against the increasing spring tension, with less change of centrifugal force and less speed variation.

There are two other, but less convenient, ways of accomplishing the same thing; if the governor travel becomes very short with the above adjustment they are better adapted. The first is by grinding spring coils on the outside to reduce the stiffness of the spring. This method has long been used for calibration of both governor and indicator springs. Increasing the number of

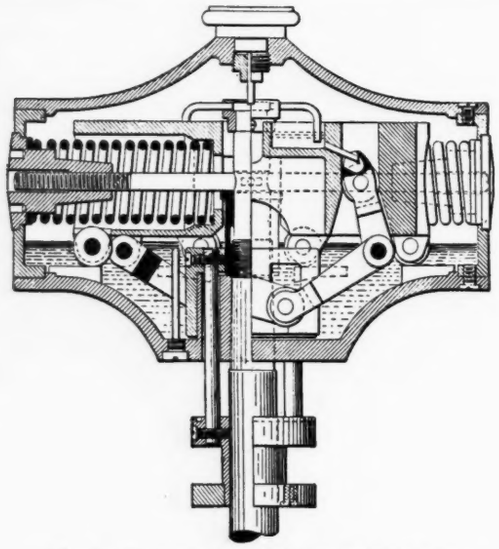


Fig. 2—Governor in which the weights move horizontally

spring coils, or increasing the spring diameter, are perhaps better ways, but both of these may be impossible for lack of room. Reducing the diameter of the wire in the spring is just as effective and calls for no additional space. All three methods require the making of new springs, and the alteration should be made by the builder.

It would seem that these operations should not be required of an engineer. But engines are operated at many different speeds, and each speed requires not only a different spring tension but another spring scale if the difference cannot be made up in the adjustable lever arm connecting governor and wedge.

If engines of different makes, or different sizes are required to parallel and share load proportionately according to their range, ability to make these adjustments is a great asset.

An engine should assume full load instantly with less than 15 per cent speed drop; this is really a design problem. It is concerned with the retardation of the engine when a great load is thrown on, as by the closing of a switch, which requires a heavy flywheel primarily; also with the acceleration of the engine when it receives additional fuel, which is best with many cylinders and a light flywheel.

Of course, if the retardation is little, due to large flywheel effect, rapid acceleration is not required; so plenty of flywheel is always good, either in unloading or loading.

At the governor the problem is purely one of governor power compared to the mass that the governor has to accelerate and the friction it has to overcome. The operator's first duty is look out for excessive friction. At any fixed load a governor operates in equilibrium. It has no power available for work unless it is displaced or the speed is changed. If the friction is excessive the governor will stop short on one side or the other of the required position, causing the engine to gain or lose speed until the friction is overcome again, a process which results in failure to meet the regulation requirements.

Wedge shafts and governors themselves are almost completely ball bearing mounted. When new they are quite as frictionless as could be desired, but, as in all ball-bearing devices having an oscillating or vibratory motion, balls are flattened, races are pitted and foreign matter accumulates just beyond the working limits under load. Yearly renewal of wedge-shaft bearings is a good precaution, and cleaning of all bearings in the governor system at even more frequent intervals is advisable. A governor placed in the engine crankcase is subject to two bad influences. Its high speed of rotation discourages lubrication of the ball-bearing mountings of the weights and at the same time subjects them to well-circulated combustion gases escaping from the pistons. If fine regula-

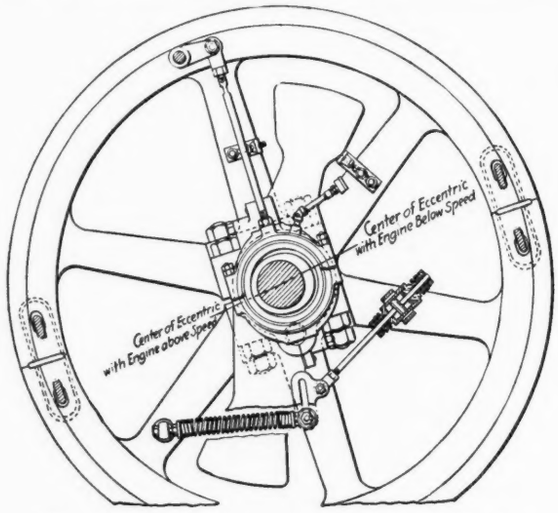


Fig. 3—A type of governor which does not regulate closely

tion and parallel operation are required the engineer must be vigilant.

While the operator may rightfully regard the following as a factory man's duty, the condition is often met by fitting a governor spring such that the governor makes almost its full possible travel for a 4 to 5 per cent speed variation. This permits use of the shortest possible governor lever adjustment and gives the governor the greatest mechanical advantage over the mechanism to be moved by it. The result is, if combined with correct bearings in the system, the most prompt response possible with the existing combination.

Elimination of oscillations is also aided by the best adjustments for full load speed drop. If the governor is required to use practically its full stroke to control the engine its over-travel (or over-regulation) is reduced by the stops limiting the governor motion.

The variation from normal speed at any fixed load should not exceed 1 per cent. This is entirely a matter of governor system friction. A well-cared-for governor and engine will control within $\frac{1}{2}$ of 1 per cent except perhaps when idling.

The governor should not hunt under any circumstances. Hunting, however, may arise from friction, as has been

stated. Its common cause is a governor spring of a scale too low to take up the increase of centrifugal force with an increase of speed. If the governor movement under change of weight, radius and speed is not met by a spring force in equilibrium for every speed and radius the mechanism will move from stop to stop, admitting fuel and shutting it off completely, with wide fluctuations of speed. A spring of greater scale will provide equilibrium between centrifugal force and spring force for each governor position and the hunting will cease. This adjustment is usually made by cutting off a few spring coils at a time until hunting stops; sometimes a spring made of heavier wire is required. Hunting is usually the result of speeding an engine beyond the number of revolutions for which the governor was originally designed or adjusted. The required governor spring scale should vary as the square of the speed to meet guarantees.

If the spring is too weak in scale and the governor travel is not fully utilized the foregoing effect may be secured by shortening the governor lever, that is, moving the link connection toward the rocker shaft. This causes the governor to move farther to effect regulation, and as the spring is stretched more the same effect is accomplished as by use of a stiffer spring and the same travel.

If forced out of position the governor should instantly assume control when released. Failure to do so is usually the result of a badly designed governor drive. To minimize the effect of engine impulses, lash in gears and crankshaft vibrations the governor should be driven through a flexible coupling provided with springs. Ordinarily the governor floats on this drive at a fairly uniform velocity. But sometimes it will surge on the drive springs and continue to do so in some critical relation between governor mass and the harmonic forces of the drive springs until the engine is shut down and restarted. This is purely a factory problem and calls for a change in drive proportions or design.

A cold engine will sometimes surge or hunt after starting and until warmed up. No adjustment of governor should be attempted with the engine in this condition. If no appreciable load is available half the cylinders should be cut out by closing the isolating valves. If the condition endures long the load should be shunted about among the cylinders to prevent any of them from being damaged. This may possibly be caused by sweating or leaking back of exhaust gases.

All governors should oscillate slightly and continuously about the equilibrium position. This is the result of engine impulses, and wedge-shaft reactions. If it were not, present regulation with the comparatively simple governors employed would not be possible. Each slight floating movement of the governor indicates that enough force has been generated by the cyclical speed variation due to the power impulses and by other reactions to overcome the governor and control mechanism friction. At each of these frequent frictionless moments the governor is entirely free to respond to additional force due to speed change, and it does so.

Lost motion in any part of the system not under spring tension must be carefully avoided. Attention to lubrication and cleanliness will delay renewals; but all small pins and clevises should be replaced or refitted when worn.

A typical governor is shown in Fig. 1. The spring-adjusting screw is at the top. The two extra trunnions on the governor collar, which is fitted with ball bearings, attach to the short vertical levers on the governor rocker shaft, which controls the spring valve wedge.

The governor mechanism shown has one peculiarity. The weights are mounted centrally and rotate concentrically on their ball bearings. A drilled hole will be noted passing entirely through each weight. At an exactly opposite location in each weight is a similarly drilled hole which is filled with lead. These lead masses in their rotation about the axis of the governor as a whole furnish the centrifugal force. The inert mass of the steel weights is used to stabilize the governor. The centrifugal force has to carry it along in effecting a movement, and the movement is therefore more deliberate.

This governor has gravity balance, because the tendency of one lead mass is to fall inward as the other tends to fall outward; the resulting effect is zero for they are bound together through the links and sleeves. The wedge shaft is also intended to have gravity balance with wedges and link connected to it.

A counterweight is provided for this purpose. It should be carefully adjusted with the governor disconnected so that the wedge shaft is well balanced and will stand anywhere it is placed.

This governor is used in connection with a fixed fuel pressure. It is evident that if the engine is idling and the fuel pressure is much reduced, the governor will have to assume a new position to permit enough fuel to pass to keep the engine up to the nominal speed. This property of the system is very useful in paralleling. The fuel pressure of the incoming unit is reduced so that the speed drops to approximately that of the loaded units.

The incoming unit is thrown on the board at the proper moment as indicated by the synchroscope, and then fuel pressure is built up, which causes the incoming unit to assume its share of the load.

A motor-driven worm-gear speed reducer is sometimes connected to the governor spring adjusting screw for switchboard operation, but is not essential for small plants. Such an arrangement is very useful in mixed plants where diesels are paralleled with several other kinds of prime movers.

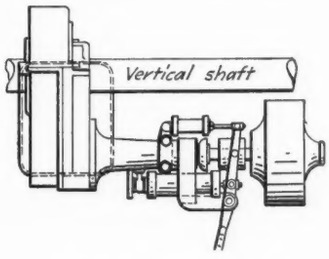


Fig. 4 — One method of driving governor through a flexible gear connection

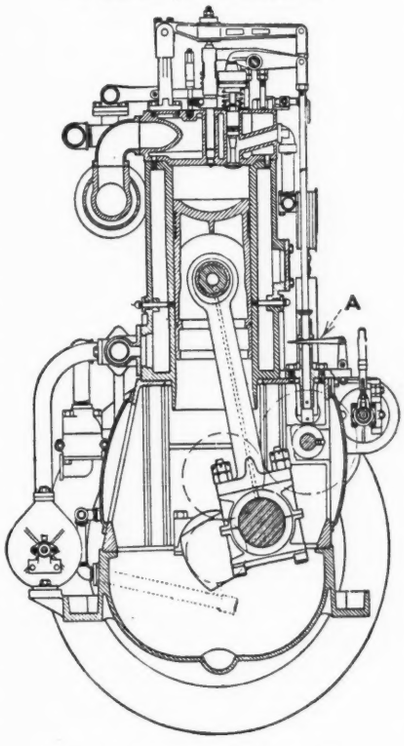


Fig. 5—Engine in which the governor acts upon the wedge A to alter the lift of the spray valve

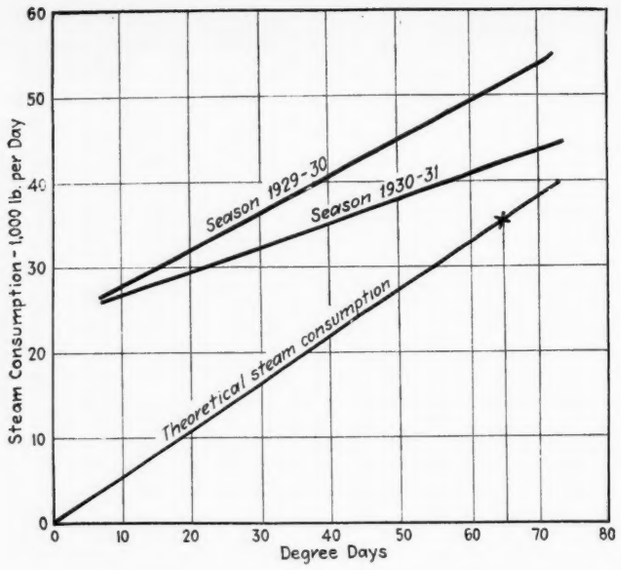


Fig. 1—Daily steam consumption and degree-day used to indicate economy of operation

Operating Methods That Save Heating Steam

Poor design and obsolete equipment are often advanced by heating system operators as the cause of high steam consumption. Even though this may be the case it does not relieve them of the responsibility of operating the equipment so as to obtain best results

•

OVERHEATING and loss of steam into the return lines because of faulty radiator traps are two main sources of heat loss that may occur in any heating system. Operating methods that reduce either of these will reduce the steam consumption for building heating. Much can be done in this direction even if the heating system has no means of control, but, of course, far greater savings can be made when control equipment is available.

In buildings having only an ordinary two-pipe vacuum system careful operation and attention to detail has made possible reductions in steam consumption of 10 per cent over previous operation and has resulted in the use of 0.7 to 0.8 lb. of steam per degree-day per cubic foot of building volume. Systems having temperature control equipment have in some cases reduced the steam consumption to 0.55 lb. of steam per degree-day per cubic foot.

To obtain the best results from any system, whether controlled or uncontrolled, it is of utmost importance that performance records be kept. Such records should at least contain hourly steam consumption, building temperature, outside temperature and temperature of system returns. A record of weather conditions such as direction and velocity of wind and whether clear, cloudy or rainy will also be useful. Without this information operation is blind and it will be impossible to determine the effect of changes in operating methods.

Leaking radiator traps are a detriment to the operation of any system, except certain orifice systems that do not require radiator traps. Where street steam is used the steam leaking past a faulty trap represents steam paid for that does no work toward heating the building. It represents a direct dollars-and-cents loss. When steam is generated by boilers in the building it may be argued that the heat in the steam leaking past traps is returned to the boiler in the feed water and therefore there is no loss of heat. However, it would be more economical to heat the feed water with exhaust steam from engine-driven pumps than with steam leaking past radiator traps. Aside from the loss of heat involved, steam leaking into the return system hinders the proper operation of the vacuum pumps and may cause some radiators to be sluggish in heating.

If a record of return temperature has been kept it will not be difficult to tell by comparison the general condition of the traps. But in a large system it is difficult to locate a leaking trap without extensive testing. It is therefore good economy to inspect and repair all of the traps on the system at the end of each heating season. The valve and seat should be examined for pitting or corrosion, and reground if necessary. The sylphon should be examined for cracks, and the unit dipped in oil before replacing in the trap body.

Overheating may be considered as of two types: that due to unnecessary heating when the building is unoccupied and that due to maintaining too high a temperature.

The steam that can be saved by reducing the first type of overheating depends largely upon the type of building. Greater savings can be made in a factory where all work stops at five and the building remains unoccupied until seven in the morning than can be made in an office building that must be kept warm until ten or eleven o'clock because of building cleaning.

In either case steam should be shut off as soon and for as long as occupancy permits. If the building is unoccupied by ten o'clock it is not necessary to keep steam on until that time. Generally steam may be turned off an hour before the building is vacated, the exact time depending on the weather and the type of building construction. In the morning, if the building is to be occupied at eight, it is necessary to turn steam on in time to have the building up to a comfortable temperature by that time.

If a record of outside and inside temperatures is kept during the night it will be possible to construct building cooling-rate curves from which the time of shutting off steam and turning it on in the morning can be determined for any weather condition. The warming-up period should be made as short as possible and in central control systems steam should be turned on full during this period.

It sometimes happens that a portion of the building is occupied twenty-four hours a day, which generally necessitates heating the entire building to maintain comfortable conditions in the small portion occupied. If such a load can be predicted when the heating system is designed the piping can be zoned so that steam can be turned off the rest of the building but supplied to the section that is occupied. If the ratio of unoccupied to occupied space is high, savings of 20 to 30 per cent are possible, which would justify a considerable rearrangement of piping to permit the zoning not orginally provided for.

Best Results Require Control Equipment

To control building temperature effectively and so reduce steam consumption to a minimum, some kind of control equipment is essential. True, some savings may be made without such equipment. For example, during mild weather steam can be shut off during the mid-day hours without much danger of complaint. To do much more than this requires a degree of supervision and attention not generally practicable.

There are about twelve different types of temperature-control systems. These can be classified as central control and control of a group of radiators by thermostat, or individual radiator thermostats. A survey reported at a recent meeting of the National District Heating Association appears to indicate that central control gives somewhat better steam consumption performance than do the other systems. It is probably true, however, that individual room thermostats result in more even room temperature.

When the heating system is controlled by thermostat little attention is required other than that necessary to keep the control in operating condition. Some of the central control systems, however, require manual setting of the control to meet heating requirements. With such systems a record of past performance is of great assistance, since it will permit of setting the control according to outside temperature with some degree of accuracy, resulting in less frequent readjustment during the day.

With certain systems the building may be divided into a number of vertical and horizontal zones and the heat supply to each zone regulated to meet requirements. Thus advantage may be taken of the sunshine on the southern exposure, with less heat supplied to it than to the north side of the building.

Considerable experience is necessary to obtain the best economy with such systems, and the engineer should not be discouraged if a showing is not made the first season.

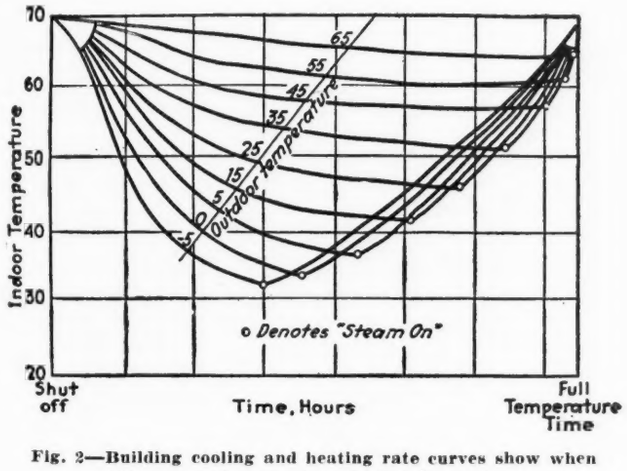


Fig. 2—Building cooling and heating rate curves show when steam must be turned on the heating system

Steam Consumption Ideal Needed

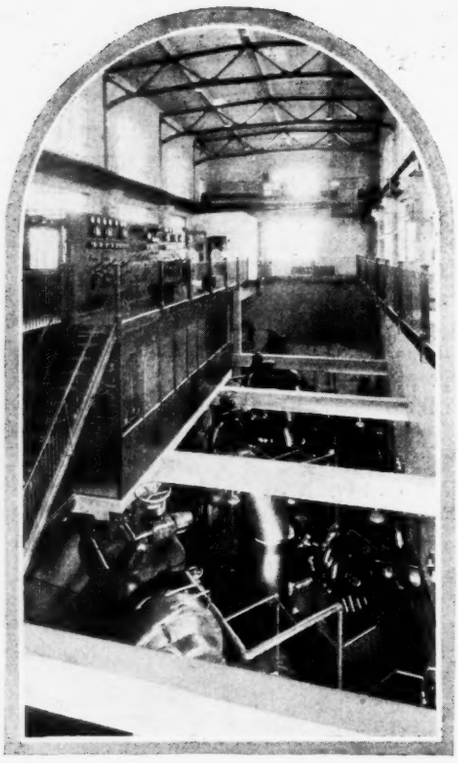
One of the factors that militates against steam consumption economy is the lack of an ideal. The power plant engineer has a theoretical efficiency that he can endeavor to approach, but the heating plant engineer seldom has a similar theoretical steam consumption ideal to strive for. If the heat-loss calculations used by the designer for determining the radiator surface requirements are available, an ideal steam consumption figure can be obtained by dividing the heat loss in B.t.u. per hour by 1,000, to convert to pounds of steam per hour, and multiplying by the number of hours per day the building is to be heated. The resulting figure is the theoretical steam consumption per day for weather conditions assumed in the design calculations. For climates similar to New York City, heating systems are generally designed for zero weather of a 65-deg.[1] day. The theoretical steam consumption for milder weather can be determined by plotting the steam consumption against the degree-days for which it was calculated and drawing a straight line through it and the origin.

This has been done in Fig. 1, and typical curves for two heating seasons added. The reduction in steam consumption during severe weather for the season 1930 to 1931 over that for 1929–1930 may be due to several factors, such as better maintenance of radiator traps, steam shut off for longer periods at night and decreased building occupancy. That these savings have been made during severe weather, with practically none during mild weather, would seem to indicate that overheating is occurring and that some means of temperature control is needed before additional savings can be obtained.

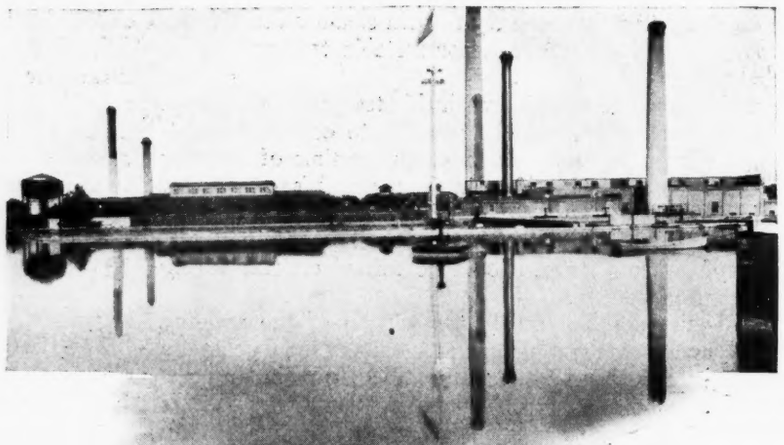
It should not be expected that the actual steam consumption will become zero on a zero-degree-day. This is because the system is usually warmed up in the morning to remove the chill in the building and because of steam condensing in the mains even though heat is turned off at the radiators. It is probable, however, that the slope of the actual steam consumption curve will be fairly close to that of the ideal if overheating is prevented during both mild and severe weather.

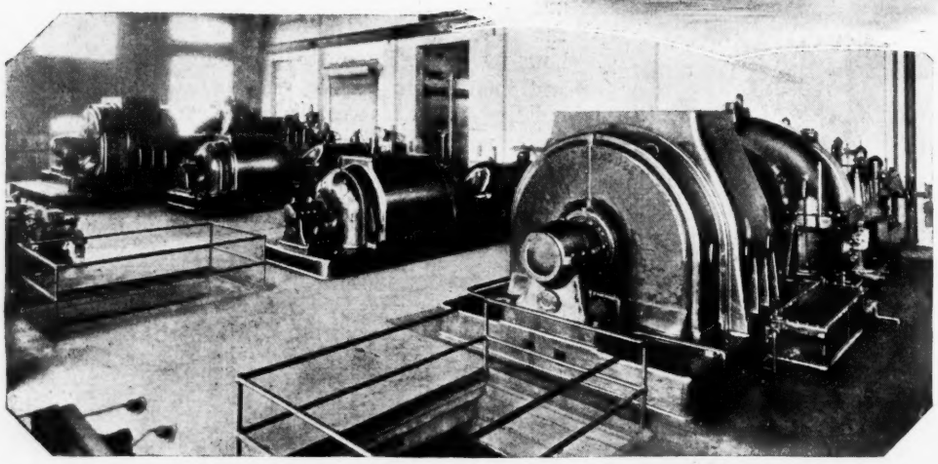
[1]A degree-day is the product of one day times the number of degrees the average outside temperature for that day is below 65 deg. F.

SOME OF THE PLANTS N.A.P.E. MEMBERS WILL SEE IN KANSAS CITY



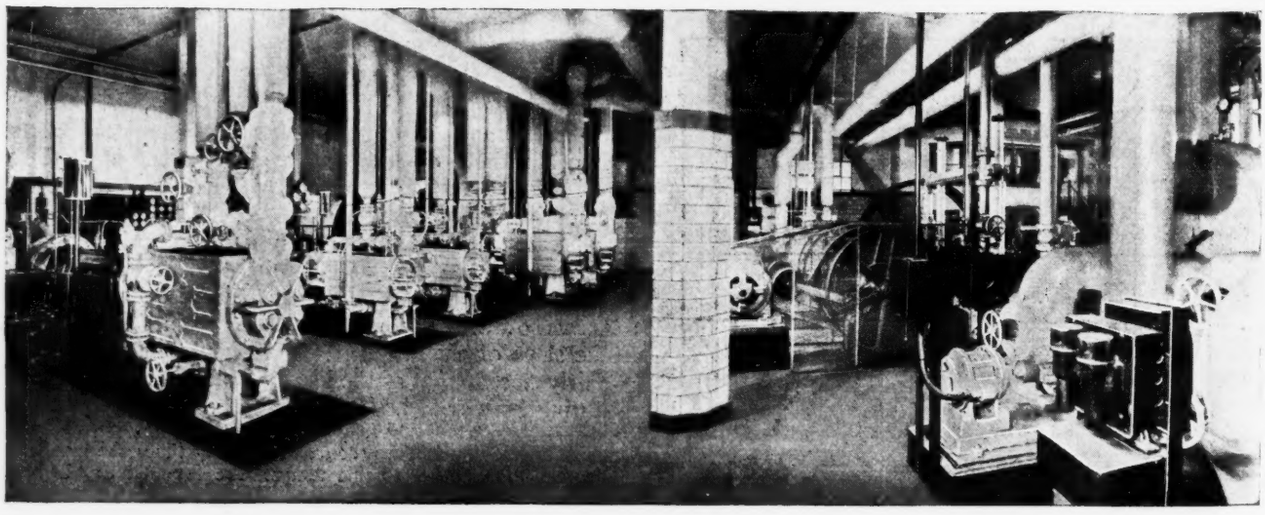
Low-lift pumping station of Kansas City, Mo., equipped with three 35- and one 20-m.g.d. single-stage centrifugal pumping units operating against a 45-ft. head

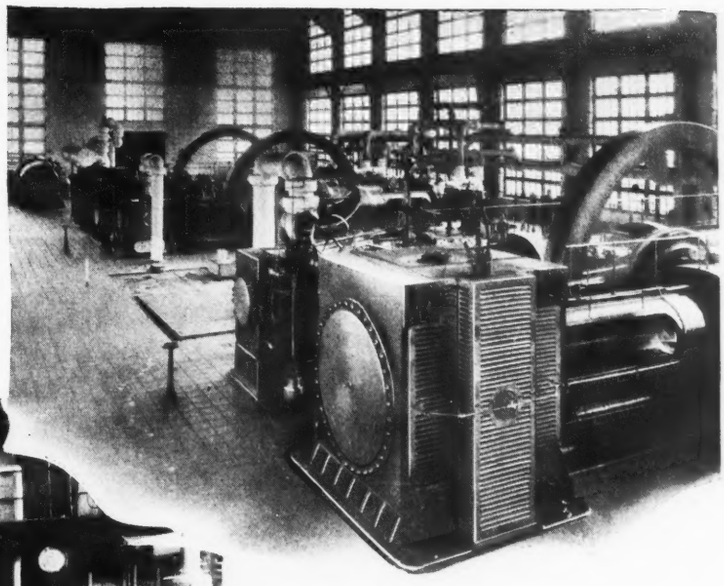




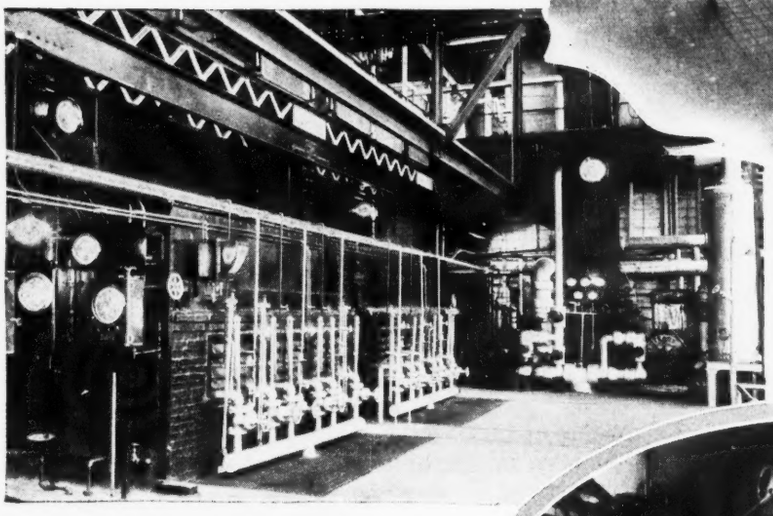
Looking over settling basin at municipal water and light plant of Kansas City, Kan., with capacities of 30 m.g.d. and 300,000 lb. of steam per hour in 16 boilers served by underfeed stokers. At the left is the turbine room with five 30,000-kw. units

Engine room of United States Cold Storage Company, which operates the largest cold-storage plant west of Chicago, with 6,000,000 cu.ft., gross of building and 1,150 tons of refrigerating capacity

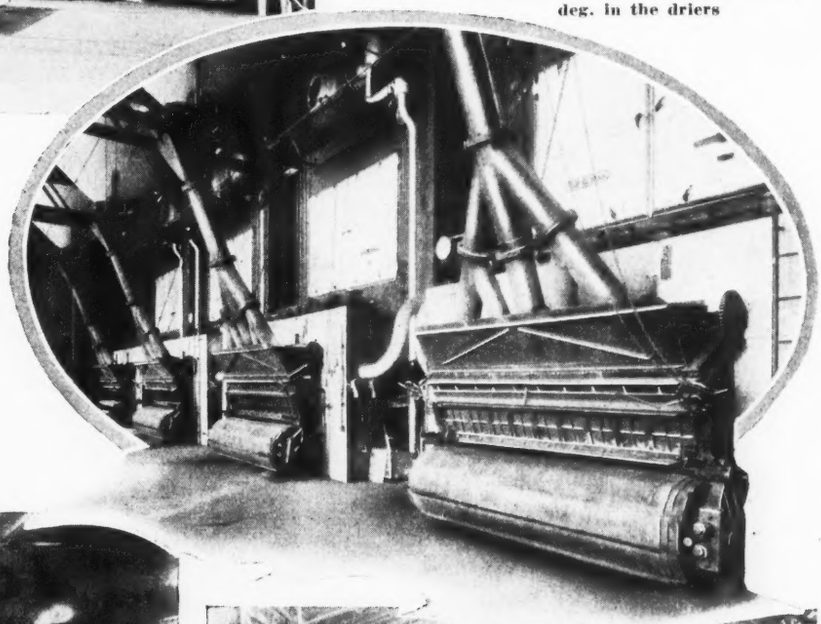




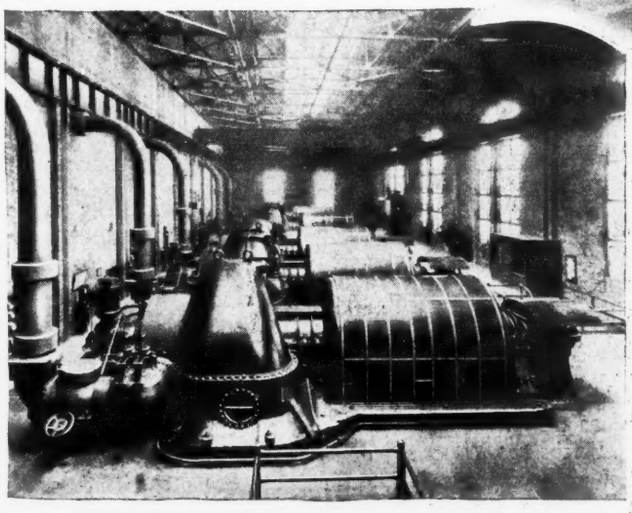
Generating and refrigerating compressor room of Armour & Company contains nine compressors with cross-compound or tandem-compound steam cylinders having a total refrigerating capacity of 3,950 tons. Shown in the foreground is an 800-ton horizontal cross-compound machine, which is said to be the largest in the country. The new boiler plant (below) contains four 6,000-sq.ft. boilers fired with natural gas

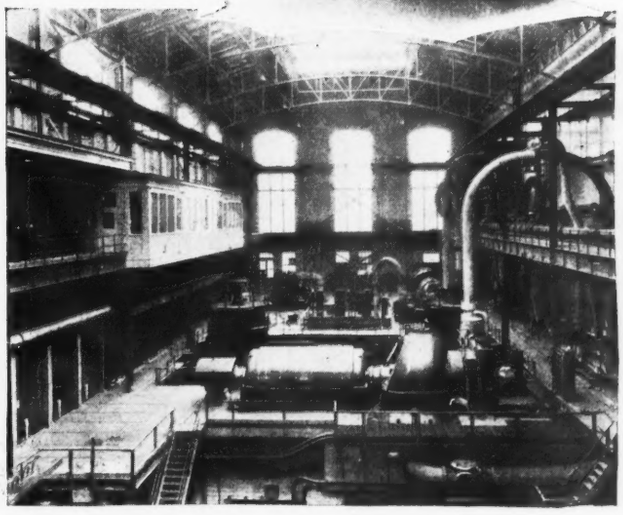


Boiler plant of Corn Products Refining Company, with four 5,000-sq. ft. boilers equipped with forced-draft chain grates. A feature is the use of flue gases for drying feed. Gas temperatures of 650 deg. from the boilers are reduced to 135 deg. in the driers



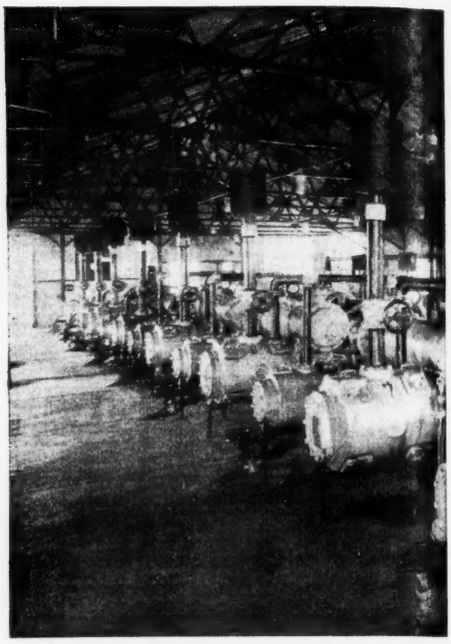
Turbine room (below) at Northeast station of the Kansas City Power & Light Company, with five main generating units, a 10,000-kw. 1,300-lb. turbine-generator and a 1,250-kw. house turbine, giving aggregate capacity of 140,250 kw.





Kansas City Power & Light Grand Ave. plant, with one 35,000-kw. condensing unit, a 10,000-kw. unit exhausting to two 10,000-kw. units and central heating and two 15,000-kw. vertical units

Care and Operation of Air Compressors



By C. H. VIVIAN

AN AIR COMPRESSOR is a comparatively simple piece of machinery, and modern units are built to operate without constant care and attention. Isolated compressors in the oil fields, in some cases, run almost continuously with only occasional visitation. The same is true of machines in such applications as air-lift water pumping at wayside railroad water stations. Automatic features have been developed to such a point that many compressor installations function positively and efficiently with only periodical checking and inspection. In general, however, compressor plants of fair size require supervision. In industrial establishments the presence of an attendant usually is demanded by other machinery, so that the care of compressors entails little or no extra labor charge.

The subject of operating and caring for compressors properly includes installation. If this preliminary work is correctly done, few troubles will arise later and the problems of the operator will be materially reduced. Accordingly, some of the features of correct installation that have a direct bearing upon the subsequent performance and life of the plant will be discussed. For the most part these are simple, but a trip through half a dozen compressor plants in any industrial community will reveal that many of them are often ignored.

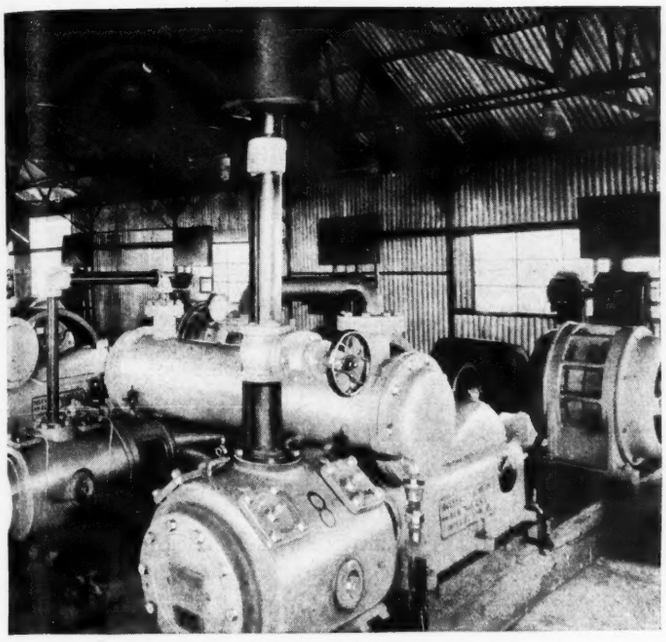
The compressor should be in a clean, light room, with ample space from walls and other machines to permit ready removal of parts and to provide easy access for inspection and cleaning. Where there is excessive dust, compressors should be placed in the main engine room or in a dust-tight inclosure.

To gain the advantages of cool intake air, the intake point should be on the outside of the building, preferably on the north or coolest side. Under average conditions this will effect a worthwhile saving. At points where it is delivered to tools, compressed air will closely approximate the shop temperature. Assuming this temperature to be 70 deg. F., with indoor intake the initial and discharge temperatures will be the same, and a compressor taking in 1,000 cu.ft. of free air per minute will deliver the same amount to the points of use. Assume that the average outdoor temperature is 40 deg. F. With outside intake, only 943 cu.ft. of free air will be required to deliver 1,000 cu.ft. of free air at the shop temperature of 70 deg. A direct saving of 5.7 per cent will be the result. Conversely, if intake air is secured from an engine room of 100 deg. temperature, it will require 1,067 cu.ft. of free air for every 1,000 cu.ft. of free air compressed and delivered to points of use at 70 deg.

The cross-sectional area of the intake duct should be at least 50 per cent of the area of the compressor piston (50 per cent of the low-pressure cylinder piston in the case of two-stage machines). If two or more units are supplied from a common intake, the main duct should equal in cross-section the sum of the cross-sections of the various take-offs to individual machines. The area of the main line may be decreased after each succeeding intake is supplied, but never to the point where it is smaller in cross-section than the combined cross-sections of the remaining take-offs. The velocity of the intake air should not exceed 1,200 ft. per minute. Low velocity reduces friction and consequent pressure loss and also helps reduce air pulsations.

The intake line should be enlarged one inch in diameter over the size at the compressor for each additional 10 ft. in length. It should be air tight to guard against the admission of dust, dirt and other foreign substances that cause rapid wear in cylinders and produce a coating on valves. It should likewise be watertight, particularly if it passes through water-bearing ground, since moisture taken into cylinders washes away the lubricant and impairs efficiency.

Brick, tile, concrete, or metal-lined wood are suitable for an intake duct. Tile pipe with cemented joints, and the whole embedded in concrete where necessary, is excellent construction. Concrete or brick ducts should be given an interior coat of waterproof paint to prevent gritty material from coming loose. Rectangular cross-



Multiple-unit compressor installation in the oil fields. Ordinarily, such plants run twenty-four hours a day with only one man in attendance per shift

sections are to be avoided, particularly in ducts of wood, as the large flat surfaces thus provided are susceptible to vibrations from air pulsations.

The point of intake should be carefully selected to exclude dust, smoke, steam and moisture. It should not be near exhaust or water pipes, but it should preferably be 8 or 10 ft. above ground level and hooded.

Use of an air filter at the intake is advisable in most places. In many industrial communities air which is apparently clean actually contains sufficient dust to damage the compressor eventually through rapid wear of valves and pistons. It is hard to segregate the economies effected by filters, but unbiased surveys conducted in various sections have shown returns on the investment of 30 per cent and upward. The principal savings are on reduced labor charges resulting from the less frequent need of cleaning the compressor. Filtering the air will also add to the ultimate life of the compressor.

For the average installation, receiver capacity must be provided sufficient to accommodate the output of the compressor for one minute. The pipe from the compressor to the receiver should be at least as large as the compressor discharge opening. Turns should be few and of long radii.

It is well to place the receiver outdoors, where it can radiate some of its heat. The gage and safety valve should, however, be placed inside the building to prevent freezing in cold weather. Inspect the safety valve regularly and test occasionally by lifting the lever or by raising the pressure to the blowing-off point. Drain the receiver of accumulated moisture at least once each day.

If a valve is used in the discharge line to the receiver, a safety valve must be placed between it and the compressor. This should be set to operate at 5 to 10 per cent above the discharge-line pressure.

When properly planned and correctly set up, a compressor plant can be maintained at high efficiency by watching comparatively few points. The provision of adequate lubrication and cooling water are of first importance, since most troubles can be traced to faulty functioning of these two agencies.

Oil companies have developed suitable lubricants for compressors and have specialists on their staffs who will assist in solving special problems that may arise. Nevertheless, a knowledge of lubrication fundamentals will stand the operator in good stead and enable him to detect and correct incipient troubles.

An air compressor develops a large amount of heat in the cylinders and requires a cylinder oil that will resist fairly high temperatures. The oil must have sufficient body, or viscosity, to sustain the weight of moving parts and maintain a proper seal between the piston rings and cylinder walls; otherwise leakage will occur and the efficiency of compressor will be lowered. At the same time, the oil must not be so heavy that it will not readily reach all wearing surfaces.

Since lubricating oils are a mixture of several compounds, various portions will be distilled or vaporized at different temperatures. The oil layer directly against a cylinder wall cooled by water jacketing will remain relatively cool, while that exposed to the heated air may be partly distilled. Its lighter portions will pass off and the heavy ends will dissolve in the oil next to the cylinder wall. The result is a tendency to build up a viscous mass, particularly if an oil of high carbon content is used.

It follows that an oil should be used which has a narrow range of distillation and relatively low viscosity, so that it will break down cleanly instead of vaporizing in stages. Pale filtered distilled oils are freest from these objectionable features. Any carbon that they produce is light and fluffy, as contrasted to the hard, flinty deposits resulting from poorly refined or unsuitable oils.

The tendency to use too much oil is most pronounced in the case of the operator who is accustomed to running steam engines. Less oil is required in the air cylinders, because the lubricant is not washed away to the same degree by condensed moisture. In general, an air cylinder equipped with the plate-type valves that predominate today requires only about one-fourth as much oil as a steam cylinder of equal size. Corliss valves require about twice as much oil as plate-type valves. Only enough oil should be used to render the valves and cylinder walls oily to the touch. Any accumulation of oil on these parts means that too much lubricant is being supplied. A surplus of oil should, of course, always be supplied to a new machine, or one that has been idle for some time.

Even though a good grade of lubricating oil is used, the heat of high compression may cause some carbon to accumulate in cylinders and around discharge valves. These deposits can best be removed with warm soapsuds, which can be introduced while the unit is operating, either by means of a hand pump or by the regular force-feed lubricator adjusted to run about ten times normal speed. These suds should take the place of the oil for a few hours. After using soapsuds, the drain cocks on the air receiver and intercooler should be opened to draw off accumulated liquid. Oil should be used again

for about half an hour before shutting down the compressor, to prevent rusting the cylinders and their fittings. Kerosene, gasoline, or other flammable, hydrocarbons should never be used for cleaning cylinders. They are highly dangerous.

The amount of oil to be supplied to crankcases is in all cases specified by the compressor manufacturer. Care should be taken to maintain it at the proper level by regular checking, to change it whenever necessary and to remove any sediment from the crankcase before refilling. This cleaning can best be done by wiping out the crankshaft with a cloth moistened with kerosene.

Piston rod stuffing boxes should be inspected frequently to guard against leakage of crankcase oil into cylinders. Adjustments of stuffing boxes should always be made while the machine is running. Glands should be tightened only enough to prevent leakage. Further tightening produces undue friction, wear on the packing and possible scoring of the piston rod. It is well to make allowance for the fact that the stuffing box on the crankcase side of the yoke is not required to hold pressure, and can, accordingly, run fairly loose.

A good quality of clean water is required for cylinder jackets, cylinder heads and intercoolers, and the discharge water from the intercooler must be fairly cold.

The use of too cool water for the high-pressure cylinder of two-stage units may cause condensation in the inlet passage of moisture contained in the air from the intercooler. Carried into the cylinder, such water will wash away the lubricant and cause undue cylinder wear. If the water is very cold it is advisable to run it through the intercooler before passing it to the high-pressure cylinder. If this is not done, the quantity of water to the cylinder should be reduced so that the discharge is at least luke warm.

Dirt, sludge and scale must not be allowed to accumulate in cylinder water jackets, as they greatly impair cooling efficiency. Loose material can be flushed out with high-pressure water streams by removing handhole covers. Scale can be removed by chipping or with acid. To clean with acid, remove the bottom plugs and completely drain the cylinders. Replace the plugs. Remove the discharge fittings from the tops of cylinders and fill the jackets with a one-to-one solution of concentrated hydrochloric (muriatic) acid and water. This should, preferably, be heated, and the acid left in the jackets until effervescence ceases, which may be as long as 10 or 12 hr. Then add more acid. If no further action takes place the scale has been removed. Drain the jacket and flush out with clean water.

When gaskets between cylinders and heads are renewed holes should be cut in them identical in size and position with those in the original gaskets furnished by the manufacturer. These holes correspond to the water ports in the cylinder and heads and are essential to the free circulation of the cooling water. New gaskets should be of the exact thickness as the originals to insure proper clearance between the piston and cylinder heads.

The pressure gage on the intercooler is a real barometer of the operation of a two-stage compressor. If the intercooler pressure is above normal it usually means that either the piston rings or the valves in the high- pressure cylinder are not doing their work properly. A subnormal intercooler pressure generally indicates that something is wrong with the valves or piston rings in the low-pressure cylinder. It is good operating practice to place an accurate intercooler gage on the gage board. The gage should be equipped with a vibration dampener to eliminate the vibration caused by the air pulsations.

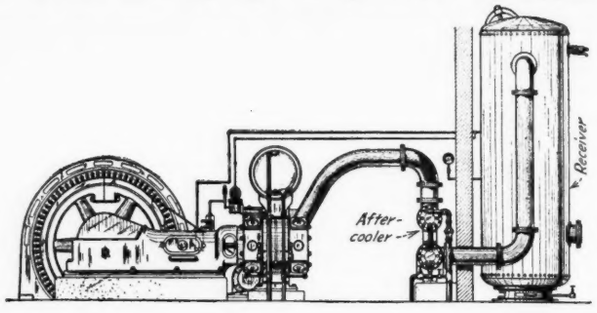
The normal intercooler pressure for two-stage units can be determined by the following computation: Divide the diameter of the low-pressure cylinder by the diameter of the high-pressure cylinder. Square the quotient and subtract one. Multiply the result by the atmospheric pressure (14.7 lb. at sea level and approximately 3 per cent less for each 1,000 ft. of altitude). The result, plus 9 per cent, gives the approximate intercooler pressure.

Care must be taken not to over-tighten main bearings. All bearings should be run as loosely as possible without knocking. That a bearing runs without undue heating is not evidence that it is properly adjusted. Bearings can be tight enough to cause unnecessary friction and still be relatively cool because the lubricating oil carries away the excess heat. Tight bearings cause stiff and sluggish operation.

It may seem superfluous to warn against leaks in air lines, yet experience shows that their significance is not generally realized. The costliness of leaks can be gaged from the fact that in a month of steady operation 9,979,200 cu.ft. of air at 100 lb. pressure will escape through a $\frac{3}{8}$-in. opening. This represents about $1,000.

On belt-driven compressors the tension should be on the under side of the belt wheel. This insures that the pressure of the crosshead shoe will be downward.

The belt should be run in the center of the pulley and wheel, should be from $\frac{1}{2}$-in. to 1 in. narrower than the wheel face and only tight enough to prevent slippage.

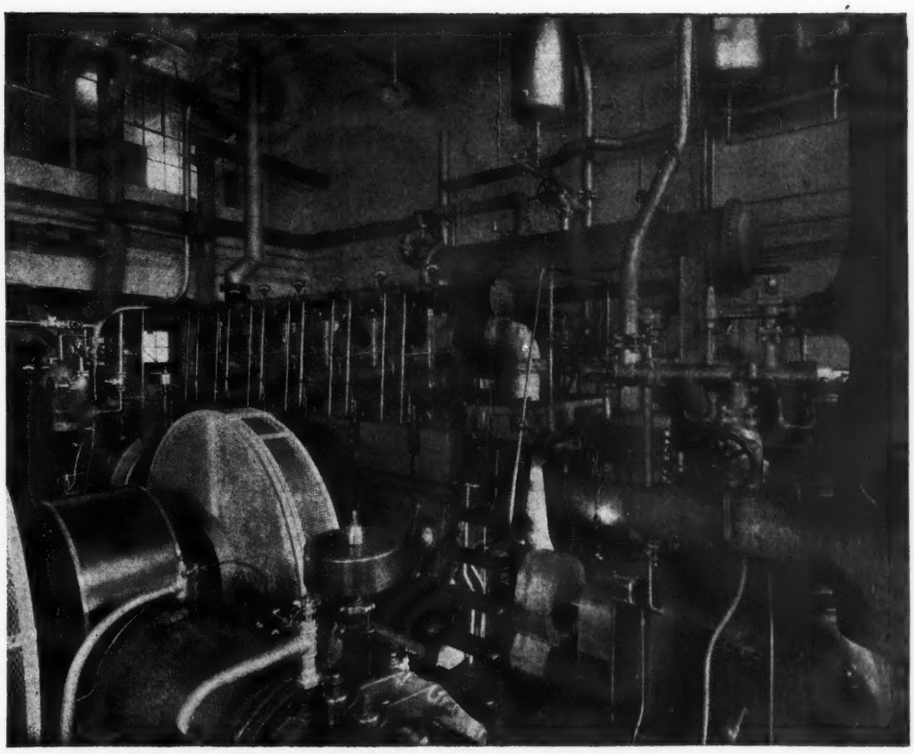


Diagrammatic sketch showing the relation between compressor, aftercooler, and air receiver as correctly practiced. The compressor and aftercooler are indoors. The receiver is close to the aftercooler, but outdoors. The air receiver gage is indoors.

A dry belt should be thoroughly cleaned with a cloth dampened with kerosene, or, when this treatment fails, by scraping with a wood or metal scraper. A sufficient number of light coats of dressing should be applied to both sides of the belt to insure penetration of the leather and to make it pliable, but not greasy.

Accumulations of oil, grease, etc., should be removed by some solvent such as naphtha or carbon tetrachloride, or by packing the belt in sawdust until it reaches a satisfactory condition. If a suitable dressing is not available, one can be made of 90 per cent tallow and 10 per cent neatsfoot oil. It is well to remember that a new belt will not act satisfactorily until broken in and that good service can not be expected from a belt operating at temperatures above 100 deg. F.

Proper care and operation of a compressor depend largely upon knowing the machine. While the rank and file of operators are fairly familiar with the construction of the units under their care, it not infrequently happens that costly, even dangerous, mistakes are made because the man responsible has not thoroughly studied the machine.



The diesel engine drives two direct-connected ammonia compressors. One machine is provided with a movable cylinder head for clearance-volume control, the second operates with two suction pressures. The arrangement permits a wide range in compressor output at constant engine speed

Handling Modern Refrigerating Plants

By C. J. CHASE

Superintendent of Manufacture
Knickerbocker Ice Company, New York City

IN THE past refrigerating plants were operated in a rather haphazard manner and according to the indications of suction and discharge pressure gages, with practically no consideration given to the heat exchanges that take place in various units of the plant. Today little or no thought is given to the pressure gages, but thermometers are placed in the various ammonia water and brine lines, and through their indications heat exchange is closely watched.

There are, however, many plants in operation that are still following the old-time methods, due in some cases, no doubt, to poor management and false economy in not supplying instruments to guide the operator. It is not unusual for such plants to operate with ammonia head pressures from 20 to 40 lb. above that theoretically required by the temperature of the cooling water. This means a loss of 10 to 15 per cent efficiency of the refrigerating unit, and from 5 to 20 per cent fuel waste. That excess head pressure is being carried is easily determined by comparing the ammonia pressure corresponding to the temperature of water leaving the condenser with the head pressure indicated by a recently checked pressure gage. Thus, for example, with a water temperature of 70 deg. leaving condenser, the ammonia tables show the corresponding pressure to be 114 lb. gage. If the pressure gage reads 135 lb., the excess head pressure being carried is 21 pounds.

To prevent this possibility the condenser, or, more logically, the receiver, should be purged of air at regular intervals. The old method of purging into a water bucket should be abandoned as being wasteful of ammonia, and any one of the efficient purgers now available used.

The ammonia temperature should be within a few degrees of the cooling-water temperature. If this is not the case it may be taken as a good indication that the condenser surface is dirty and in need of cleaning. It is not uncommon for operators to blame excessive head pressure on the type of condenser. Actually, however, efficient heat exchange can be obtained with practically all types of condensers.

It is surprising to note the great advance made in recent years with ice tanks; in fact, tanks not five years old are obsolete. The modern or reconstructed tanks have increased agitation to such an extent that brine temperatures do not vary more than 0.7 deg. in any part of the tank. They have also been baffled so that the flow of

brine is practically identical everywhere. To eliminate the possibility of careless handling, float controls are installed which can be arranged to carry the refrigerating element at a predetermined level. The above features have in many cases increased plant capacities 10 to 15 per cent and resulted in temperatures of suction ammonia gas leaving the tanks and brine being within 0 to 3 deg. of each other.

A few years ago little consideration was given to forecooler tanks. In practically every ice plant built in recent years compressors are installed that carry two suction pressures, commonly known as multiple-effect compressors. The low suction pressure carries the load from ice tanks, store houses and anterooms, and the high suction pressure carries the load of the forecooler. With this equipment operators have been able to improve efficiencies 10 to 20 per cent. With clean cooling surface and proper size forecooler it should be possible to precool the water used for ice to within a few degrees of the temperature corresponding to the ammonia pressure in the forecooler. Thus by varying the high suction pressure almost any desired forecooler water temperature can be obtained. Generally a spring-loaded pressure valve is provided, which at all times maintains the desired pressure to the high-suction side of the compressor and thus eliminates the necessity of continuous watching by the operator.

The forecooler temperature to be carried is determined by the quality of the ice manufactured. Too cold water results in a white film that may extend 12 or more inches up from the bottom of the ice cake, materially depreciating the appearance of the ice. However, the colder the water leaving the forecooler the greater the improvement in efficiency, and the water should be carried at as low a temperature as possible without causing the white film on the bottom of the ice cake. This temperature has to be found by experiment, as it is influenced by the characteristics of the water and the water treatment.

Brine density should be checked frequently so that it may be maintained at as low concentration as possible consistent with the temperature at which it is used. A leeway of 10 to 15 deg. Baumé is good practice. Maintaining higher brine concentration than necessary is expensive, because of the additional calcium or salt required, and, in addition, the load on the agitators and pumps handling it is increased because of its greater weight and viscosity. But these losses are small when compared with that incurred when too low a density is permitted, under which condition the heat transfer will be greatly reduced because of ice forming on the coils or outside of the ice cans. The suction pressure will go down and the compressor freeze back readily, resulting in loss of efficiency.

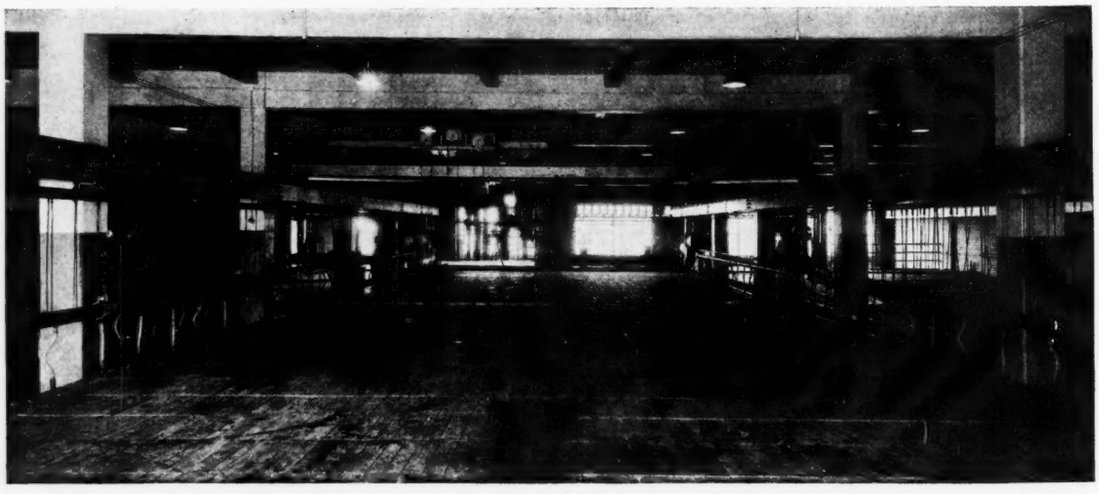
Installations of various automatic alarms, such as on the head pressure side, cooling water pumps, etc., greatly facilitate plant operation, and have been found to pay large dividends. Such alarms relieve the operators' time to such an extent that it is possible for them to take care of many maintenance jobs and details whose neglect may be costly in a short time. For example, testing ammonia condensers for leaks. This should be done regularly at least three times a day. Such procedure will save many dollars, for through even a small leak a large amount of ammonia can be lost during the course of a week. It is surprising what such a small detail as wiping the compressor or engine will develop. Frequently a bolt is found loose, or a pound discovered, that before many days would have resulted in serious trouble.

Direct connection of ammonia compressors to motor or diesel engine has resulted in their operation at considerably higher speeds. Where such units are installed the thermometers should by all means be placed in the suction line to guide the operator. They will save many anxious moments, as thermometers will indicate conditions in the compressor that are not shown by gages. However, the experienced operator will continually compare thermometers and gages for the attainment of best efficiency.

Many plants formerly left suction and precooled-liquid lines uncovered, a wasteful practice from which considerable loss may result, depending on the size and length of runs. Most of these lines are now insulated, and dry suction gas is insured by accumulators or surge tanks in the suction line.

A record should be made of practically every temperature and pressure carried in the plant, and the data preserved indefinitely. By comparing present operating methods with those of last year, or with the record taken when equipment was new, it is easy to determine where and why efficiency is being lost, and to take whatever steps may be necessary to place the equipment in its original condition.

Records should also embrace such details as the cost per ton for labor, handling, fuel or power, and maintenance. With this information at hand the engineer will have a practical idea of just what performance may be expected of his plant.

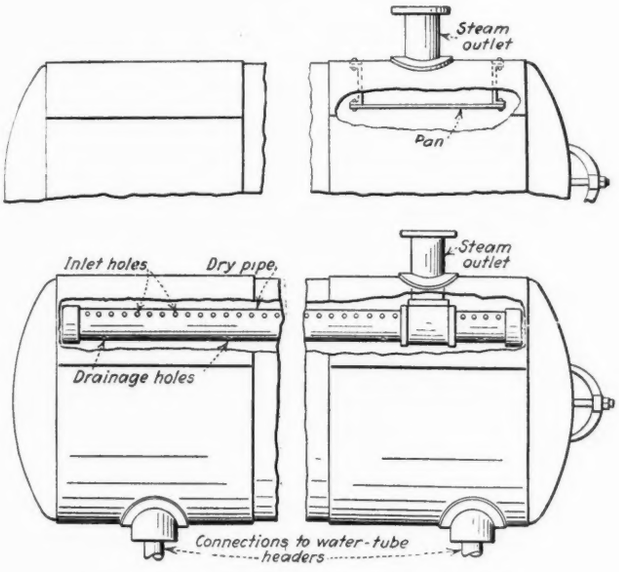


A modern can room, showing pendulum-type agitators and crane ready to lift cans from the tank

...RIGHT OUT OF THE PLANT...

Steadying the Level in Water-Tube Boilers

FLUCTUATIONS in the demand for steam for various processes in a manufacturing works were both frequent and excessive. The steam was generated in a single water-tube boiler of the horizontal-drum type. The outlet was in the rear shell-course of the drum. It opened directly from the steam space, no device intervening to prevent priming or siphoning of the water under heavy drafts of steam. As a consequence the water level was erratic.



Pan suspended under outlet and long dry pipe that prevented priming

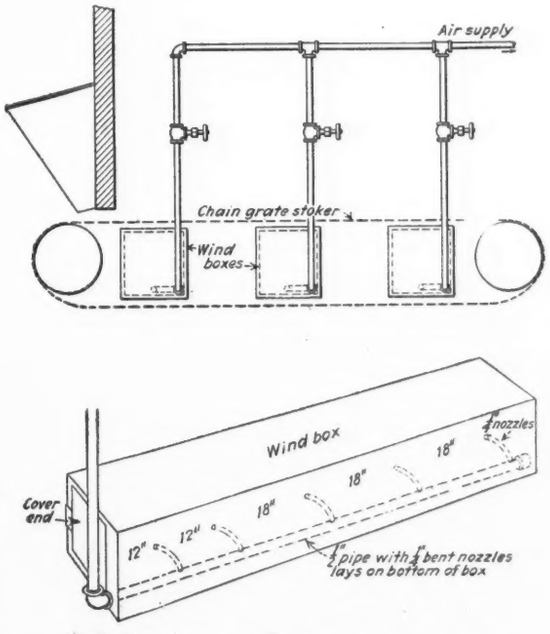
To cure the trouble the engineer first adopted the plan of hanging a flat pan under the steam outlet, as shown in the upper view. The pan was of considerable area, the idea being to blanket the rush of steam bubbles from the surface of the water in the region of the outlet, thereby keeping the water from piling up. But the scheme did not work. The water in the gage glass still continued to drop out of sight when the demand for steam suddenly became excessive and to climb nearly to the top when the excessive flow as suddenly ceased.

So the engineer discarded the suspended pan and installed the dry pipe shown in the lower view. This dry pipe worked satisfactorily. The fluctuations of the water level, as seen in the gage glass, now rarely exceed 2 in. in height. Apparently the dry pipe gathers the steam for the outlet flow uniformly from end to end of the steam space. There is no localization of a copious liberation of steam from the water directly under the outlet nozzle. Hence there is no priming. Along the upper side of the pipe are two rows of holes through which the steam enters from the top of the drum. The ends being capped, a few small holes were drilled in the bottom of the pipe to provide drainage.

Chicago, Ill. D. J. ALLISON.

Air Ejector for Chain-Grate Siftings

WE EXPERIENCED a good deal of trouble in removing the fine coal and dust that accumulated in the windboxes of our chain-grate stokers. Last month we equipped all of the windboxes with air ejectors as shown in illustration. Now all that is necessary to clean the boxes is to remove the cover and open the air valve, and the boxes are blown clean in a few minutes.



Arrangement of air ejector nozzles in wind box

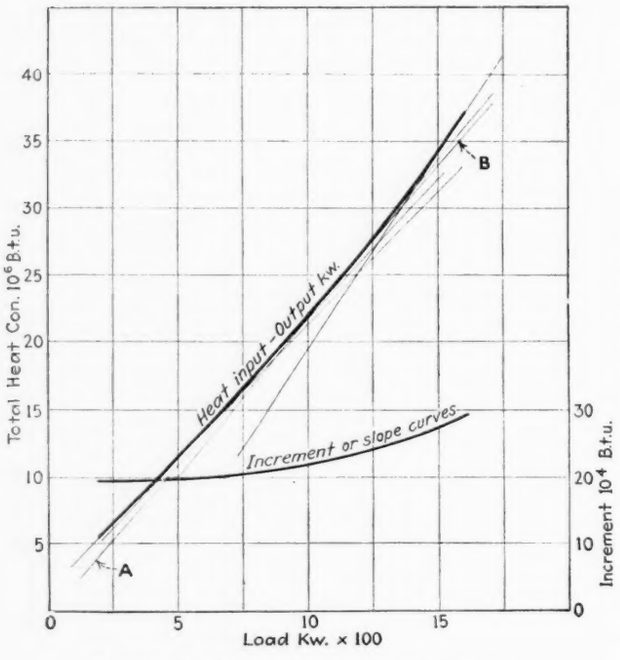
It occurred to me that this might be of help to those who use chain-grate stokers burning a fine grade of coal.

Wilkes-Barre, Pa. THOMAS M. STREET.

Division of Turbine Load by the Increment Method

IN THE ARTICLE "Load Division by Increment Method," on page 911 of the June 9 number of *Power,* Mr. Hahn has calculated the increment curves from the heat consumption curves. Since the latter are plotted as smooth curves, it follows that the increment curves must also be smooth, instead of irregular as shown in his figure. This is due to the fact that he calculated the increment rate to only two significant figures, whereas three would have given a smoother curve.

The accompanying curves show a preferable method for arriving at the increment rate curve. This is done graphically by using a total heat input-output curve to which tangents are drawn to determine the slope at any point. The slope of a tangent is found by dividing the difference between the ordinates at any two points



Graphical method of deriving increment curve

A B by the difference between the abscissa at these points: $\frac{(35 - 4)10^6}{(16 - 2)10^2} = 2.21 \times 10^4$.

I think this is the method usually used. Mr. Hahn's method, however, would also have yielded the same results, although lengthy, had he interpreted his data correctly.

G. V. WILLIAMSON.

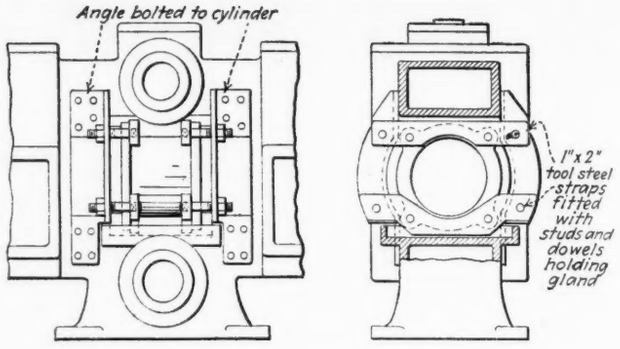
St. Louis, Mo.

Repairs to Outside-Packed Plunger Pump

THE ACCOMPANYING ILLUSTRATION shows how repairs were made to an old type of outside-packed plunger pump. The gland stud holes had been redrilled and retapped numerous times, as the result of abuse, or the use of the wrong kind of packing, until it became impossible to renew them further and meant the replacement of the water cylinder. The drawing is self-explanatory. Since the repairs were made the pump has operated satisfactorily.

C. H. PAEPLON.

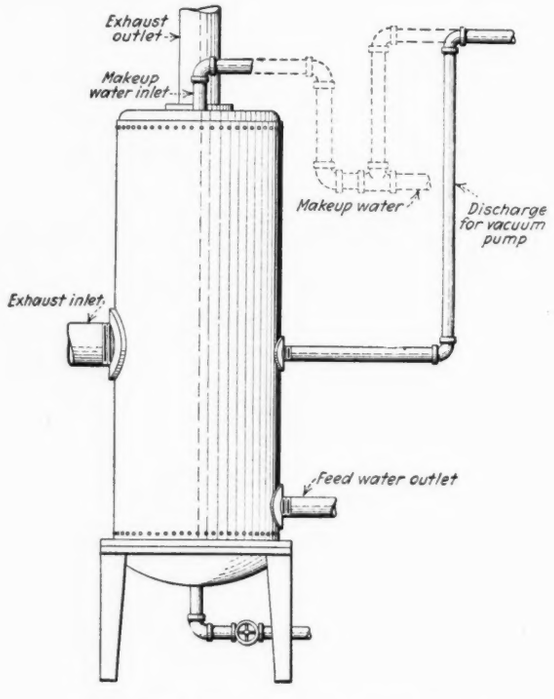
Buffalo, N. Y.



Angles were bolted to the cylinder to take the studs

Remedying Troublesome Feed-Water Heater

THE DISCHARGE PIPE from a vacuum pump attached to a heating system was connected to an open feed-water heater directly opposite the orifice through which the exhaust steam entered, as indicated in the accompanying sketch. For some unaccountable reason the heater would not raise the temperature of the feed water to the degree which the quantity of entering exhaust steam seemed to warrant. Disturbing noises also occurred in the vacuum pump's discharge pipe, and occasionally a severe water-hammer would jar the horizontal section from end to end. The temperature of the condensate passing through the discharge line was over 100 deg. at all times, and often as high as 150 degrees.



Rearranged piping eliminates water-hammer

Entering the heater at the top, the supply water rained down from a series of pans set one below the other, while the steam passed upward through the thin sheets of falling water. The engineer in charge thought that the trouble might be cured by introducing the discharge from the vacuum pump into the top of the heater. So he changed the piping as indicated by the dotted lines, arranging a pocket in the piping into which he tapped the supply of make-up water. Altering the connections in this manner stopped the water-hammer and gave a higher feed-water temperature. A. J. DIXON.

St. Louis, Mo.

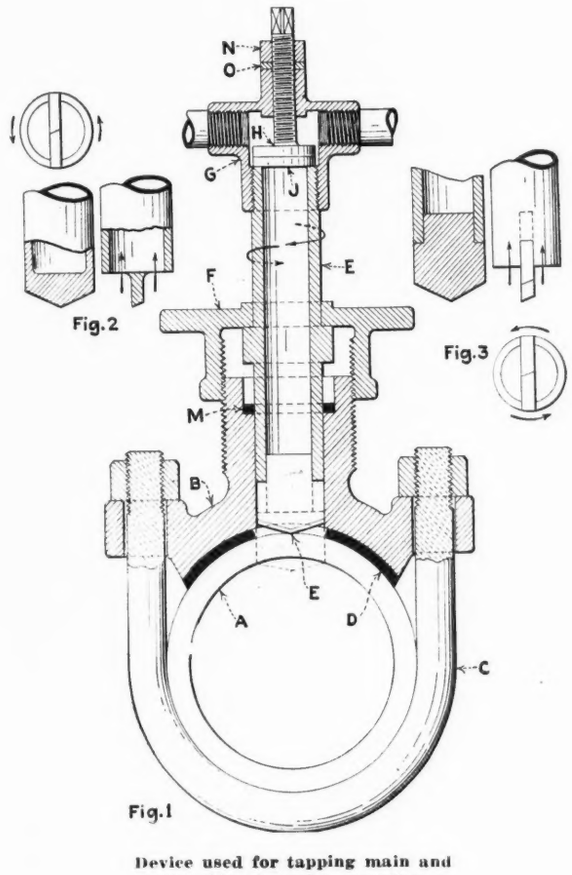
Tapping a Steam Main Under Pressure

HAVING OCCASION to attach a 2-in. branch to an 8-in. high-pressure steam main while pressure was on the main, we made up the device illustrated: *A* is the pressure main, *B* a saddle of semi-steel and *C* a U-bolt holding the saddle to the pipe, with a layer of packing inserted between the two. *E* is the ferrule or branch and is provided with a piercing cutter in the form of a drill. This cutter may be integral with the ferrule, as shown in Fig. 2, or it may be separate and fixed by brazing, as in Fig. 3. If fixed by brazing, the cutter must be of air-hardened steel, so that the temper is not affected during the brazing operations. When the ferrule is made with the drill integral it must, obviously, be made of material that will either temper or case-harden.

The method used to prevent escape of pressure during the operation of piercing the main will be clear from a study of the illustration. The saddle *B*, being fixed to the main and with the point of the drill touching the main at *E*, the double-handled nut is used for the feed, while the tee-piece *G* with pieces of ordinary piping for handles, is for rotating the drill. When the tee-piece has been screwed tightly onto ferrule *E* the brass flanged screw *H* is screwed down onto the machined face of the ferrule, with a lead washer interposed between them.

Rotation of the ferrule by the tee-piece conjointly with the feeding device enables the drill to pierce the main, the pressure being sealed by the lead washer *J*. When the pipe service has been completed it is only necessary to screw back the brass flanged screw *H* and lock nut *N* on the lead washer. J. T. TOWLSON.

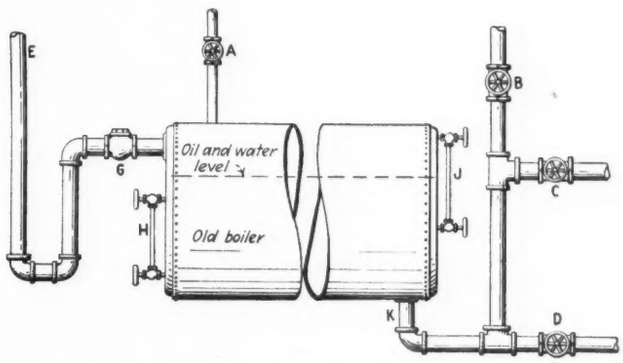
London, England.



Device used for tapping main and attaching branch connection

Condensate Receiver Made From Discarded Boiler Drum

RETURN-TUBULAR BOILERS or drums of water-tube boilers that have been discarded owing to their becoming unsafe for the normal operating pressure make excellent



Discarded boiler drum connected as a condensate receiver

receivers and oil separators for condensate returns. The illustration shows exactly what was done in one case.

Connection *A* is for steam, or air pressure, as happens to be the most convenient, *B* is the suction to a steam pump, *C* is an overflow and *D* is a supply for an injector. *E* is the drip supply to the tank. Two gage glasses are used to indicate the high- and low-water level.

In operation, valves *A* and *C* are closed when *B* or *D* is in use to supply pump or injector. To blow out the tank, *C* is opened and *B* and *D* closed and then valve *A* is opened. This outfit, made mostly from discarded material, saved a lot of water that was formerly allowed to go to waste. J. E. NOBLE.

Toronto, Ont.

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PARALLEL OPERATION OF FANS—Only fans with rising pressure characteristics should be used for parallel operation. A fan is of rising pressure characteristic type when the pressure curve rises continuously from free delivery to no delivery condition. If two or more fans discharge into the same duct the connections from the fan discharge to the duct should be designed so that the frictional loss in each case between the fan discharge and the duct will be equal.

From Among Readers' Problems

Conducted by
L. H. MORRISON

ACCELERATING TIME OF FREE DISCHARGE—*How is the interval of time computed within which a gas or liquid reaches its theoretical velocity or flow from an orifice under pressure, assuming the valve to open instantly?* G. W. P.

The time would be the same as that required for a body to fall in a vacuum from the height of a column of gas required to produce the head of pressure under which the discharge takes place. Knowing the weight of gas or liquid per cubic foot, the head in feet required to create a given pressure per square inch would be

$$h = \frac{\textit{pressure per sq.in.} \times 144}{\textit{wt. per cu.ft.}},$$

and, as the formula for falling bodies, in which t equals the time in seconds, is

$$t = \frac{2h}{g}$$

where $g = 32.16$ ft. per sec.^{2} the time in seconds to acquire the velocity due to the head would be

$$t = \frac{2 \times \textit{pressure per sq.in.} \times 144}{32.16 \times \textit{wt. per cu.ft.}}$$

OPERATING SEQUENCE OF BOILER BLOWDOWN VALVES—*Each of our boilers is equiped with two blowoff valves. In blowing down, which valve should be opened first, the one nearest the boiler or the one farthest away.* R.A.C.

The purpose of installing two valves on a boiler blowdown is safety and tightness. The tightness is secured by operating the valves in the same sequence at each operation. The preserving of this fixed sequence is promoted when the two valves are of a distinctly different type, such as a quarter-turn cock and a screw-actuated valve.

Where this combination is used, the sequence of operation should be: open cock first, open screw-actuated valve; close screw-actuated valve, close plug cock. With an arrangement of this kind the controlling factor of the sequence is not the position of the valve but its type.

The preferred position for a lever-operated blowdown valve is next to the boiler, with a screw-actuated valve beyond it. This is particularly so if more than one boiler discharges to a common blowoff header. In such an installation the correct sequence is: open valve next to boiler first, open the outside valve and blow; close outside valve, close valve next to boiler.

Where two valves of the same general design are used, probably the best way of assuring proper operation is to fix an instruction plate to the handwheel or body of the valve, the instruction on each valve to be: open first, close last; open last, close first.

The question is not one of whether to open the inside valve first and the outside valve last (or vice versa), but one of maintaining the same sequence of operation for both valves so that one may be preserved and the other perform its function of added safety and blowdown control.

DURABILITY OF HEAT INSULATION—*What tests should be made to compare the durability of heat insulation made by different manufacturers?* J. N. D.

Various types of mechanical tests have been employed to indicate the service that can be expected from molded insulation. A test that has been used extensively in the past to determine this important quality has been the transverse loading test. In performing it two knife edges spaced about 10 in. apart are used to support the test blocks. The load is gradually applied to the center of the span until the test piece fails.

The transverse test alone does not give all of the information necessary to determine the durability characteristics of the molded insulation. An important characteristic undetermined by this test is its brittleness and tendency to crack under suddenly applied stress. To determine brittleness, weights are dropped measured distances upon a test specimen, and the work necessary for breakdown is measured in foot-pounds of impact resistance.

A third characteristic that should be determined is that of hardness. For this purpose a penetration test has been devised, in which a $\frac{1}{4}$-in. rod tapered at the end is made to penetrate the insulation tested under a given load, usually about 10 lb. The distance the rod penetrates is taken as a measure of comparative hardness. The indications from all three tests must all be considered in comparing the durability of various makes of insulation.

PREVIOUS QUESTION DISCUSSED BY READERS

THE QUESTION

SOME of the squirrel-cage motors in our plant are giving trouble with loose connections between the rotor bars and end rings. The bars are bolted and soldered together. What is the best way to make these connections to prevent their working loose? R.E.H.

THE FIRST THING that should be done to prevent the rotor bars from working loose at the end rings is to find the cause and remove it. I have seen cases where temporary excessive loads burned off bars that were welded to the end rings. Perhaps the motor is considered large enough to carry the load because it did at one time. Present-day tendency is to speed up production. Often this is done without giving thought to the motive power. On the other hand, the physical condition of the machinery driven by a motor may be allowed to run down. Both place an undue burden on the motor, which will react on its weakest parts.

On some of the older-type motors that have their rotor bars bolted and soldered the bars are often insulated in the slots with fiber. I have seen the bars become loose in the slots and vibrate, loosening the screws in the rings.

In an emergency I have made a temporary repair by driving thin steel or iron wedges in at each end of each bar that appears loose in the slots. The wedges should be driven in very tight so that they will not work out and damage the stator winding. Insulation on the bars is of little consequence. Modern squirrel-cage motors do not have their bars insulated from the iron. Worn bearings may cause the rotor bars to loosen, from excessive heat caused by friction between the rotor and stator.

The best method of making a permanent job is electric welding of the bars and end rings. But this will not apply to a motor that is heavily overloaded, because the welded bars may burn off near the end rings.

J. C. STILWELL.
Pittsburgh, Pa.

THE QUESTION brings to mind experiences of fifteen or twenty years ago in making such repairs to rotor windings. The end rings were made of overlapping segments of flat copper with punched holes through which the rotor bars were forced. There were small spacers of the same stock between segments to provide ventilation for the end rings. The number of segments through which the rotor bars passed varied with the rating of the motor. After assembly the whole end ring was slowly rotated in a bath of solder. If the starting period was too long or if excessive loads were applied to the motor the solder would sometimes be thrown out and arcing would occur between the bars and end rings segments.

When arcing occurred the contact surfaces were badly burned and the rotor bars were sometimes burned away from the end rings. The only way to make a satisfactory repair was to strip the rotor winding completely, carefully clean all holes in end-ring segments and rotor bar ends, tin all pieces and reassemble the winding in the rotor core. After assembling, the bars and end rings were soldered by placing the rotor at an angle so that one ring could dip into a pan of hot solder.

Rotors which exhibited this sort of trouble were assumed to be subjected to excessive loads, so we usually made up a solder of approximately five parts of lead to one of tin. Such a solder was hard to keep hot, but once it was spread on the joints it would stand much greater heat before melting than the softer solder.

If faced with this problem today I would call in a welder and have the rings and bars welded together on both ends of the rotor and turned off to a slightly smaller diameter than the rotor core. The matter of balance will have little or no effect unless the motor operates at high speed. However, a trial for static balance on knife edges can easily be made. W. A. WYATT.

Bristol, Conn.

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OUR EXPERIENCE has been that trouble with the rotor bars where they are joined to the end rings is due to overloaded motor, loose bars in slots, excessive vibration and poorly made joints. In correcting this difficulty, first the end rings should be removed and each bar checked for tightness in its slot; those found loose should be tightened. Ordinary solder is usually unsatisfactory on the joints; in replacing the end rings the so-called silver solder should be used, carbon electrodes being used to heat the joints. The end rings and ends of bars should be well tinned before replacing the rings.

The heads of the bolts should be tinned as well as the nuts where they are used. To make the joints, replace the end rings and connect the bars firmly to them with the bolts. Select a bar that lies in a horizontal plane and heat it with the carbons until the solder flows, then flow solder into the joint, and while hot tighten the bolt. After

A Question for Our Readers

CAN static electricity be prevented from forming in belts? It can be drained off by mounting a grounded metal comb near the belt, but in the presence of explosive fumes and dust it is desirable to prevent the creation of static. If any readers have solved this problem I should appreciate learning of their experience. S.W.A.

Suitable answers from readers, if received promptly, will be paid for[1] when published.

▼

the bolt is tight it should be soldered to the bar and excess solder wiped off. Care should be exercised not to overheat the joints. We have found that this method of making the connections will end the trouble with loose joints when it is not in the design of the machine.

B. M. DUNLAP.

Merced Falls, Calif.

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WE HAD considerable trouble from loose rotor bar connections in our 10-hp. motors. After several attempts at resoldering failed, welding the end rings stopped the trouble. We were afraid at first that the high welding temperature would ruin the insulation. The rotor was stood on end in water with the ends of the bars just above the surface. After welding in this position the rotor was dried out and balanced. Later it was found that the welding could be done without putting the rotors in water. Welding proved to be a permanent solution for the trouble. The cost of doing the job was $6, compared to $40 for soldering.

THOMAS SHEEHAN.

New York City.

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I AM REMINDED of some work I supervised a number of years ago on some old squirrel-cage motors. My experience at that time indicated that loose bars could be effectively soldered by using pure tin, with an oxy-acetylene torch for heating the connections to be soldered. Tin will readily coat copper and form a tough bond at the surface. It is only necessary to clean the parts to be soldered and then apply the torch and heat sufficiently to cause the copper bars and end rings to melt the tin when placed in contact. Allow plenty of tin to permeate the space between the bar and end ring. J. C. NUTTER.

Quebec, Que.

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A SOLDER which melts at high temperature should be used, and a good soldering solution with ample heat to put the solder in every available space will correct the trouble. We use plumbers' solder, 50 per cent lead and 50 per cent tin, and a soldering solution made by dissolving as much zinc as possible in chemically pure muriatic acid. After it has cooled strain out the sediment and add a piece of salammoniac the size of a pea to each ounce. Put some of this solution on the joint just as heating is begun and a little more after the solder starts to melt.

A lead burning torch or small oxy-acetylene torch is excellent for the heating. Bolts should fit the holes reasonably tight and should be pulled up tight. If the solder is made sufficiently fluid by heat, capillary attraction will draw the solder into every space. Care should be taken not to spill the soldering solution on the insulation, and all joints should be washed with soda and water after the job is complete.

F. E. BRODIE.

Leesville, S. C.

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IN OUR PLANT we have a number of old-type motors that gave trouble with loose rotor bars. We removed the end rings and draw-filed the contact surfaces until they were smooth and clean. The sides of the copper bars were cleaned with a file. For cleaning the face of the bar that comes in contact with the end ring we use a portable hand grinder. By using a small wheel grinder, the bars can be cleaned on a small rotor without taking them out of the slots.

After the bars and rings are cleaned the latter are put in place and bolted to the bars. Just enough bolts are used to hold the rings in position, and the bars are brazed to the rings. This is done with an oxy-acetylene welding outfit using a tip of the proper size for the work. We have had the best results with a special brazing rod manufactured by Westinghouse. It flows freely, and it is not necessary to use a flux. This rod works equally well with end rings of either copper or brass. As the brazing progresses around the ring the bolts that were used to hold the ring in place are removed.

After the brazing is completed the squirrel cage is centered and the bars wedged in the slots. Some types of rotors do not require any centering, as the rings are provided with lugs that rest against the core.

The last operation is balancing the rotor. When this is completed the rotor is ready to go into service. I have had a considerable number of rotors repaired in this way, and have yet to have one develop any trouble with the bars working loose. S. H. RHODES.

Howes Cave, N. Y.

[1]As an alternative to cash payment for answers published, readers may select any one of the following books. (Be sure to state the book desired):

Morrison's *American Diesel Engines*; Walker and Crocker's *Piping Handbook*; Norris and Therkeisen's *Heat Power*; Emswiler's *Thermodynamics*; Church's *Steam Turbines*; Uehling's *Heat Loss Analysis*; Croft's *Steam Power Plant Auxiliaries and Accessories*; Powell's *Boiler Feed Water Purification*; Osborne's *Power Plant Lubrication*; Moyer and Fritz' *Refrigeration*; Rietschel-Brabbee's *Heating and Ventilation*; Annett's *Electric Elevators*.

High-Pressure Boiler and Turbine Operation at Northeast Station*

By J. A. KEETH
Assistant to Vice-President
Kansas City Power & Light Co.

THE high-pressure equipment at Northeast Station, Kansas City, Mo., consists of two 17,000-sq.ft., 1,400-lb. boilers and one 10,000-kw., 1,200-lb. turbine. The boilers are arranged for pulverized-coal firing, using the unit system. Furnaces are completely water-walled with radiant reheaters, originally shielded by water-wall tubes located in the side walls. The superheater is of the convection type, located in the first pass of the boiler.

The early months of the operation of this installation involved frequent interruptions. However, after the first few weeks practically all of the outages were due to the reheaters. It was apparent from the start that the reheaters had sufficient surface, under the furnace conditions that prevailed, to raise the temperature of the exhaust steam to a point even approximating that desired. The many changes made in the reheaters and burners, and also air adjustments, involved much "cutting and trying." This resulted in one or the other of the boilers being out of service almost continually until the changes completed in July, 1930, had been made. After the July changes were made, reliable service was obtained from the equipment until February, 1931. At that time leaks began to develop in the reheater tubes which, examination showed, were due to overheating of the tube walls. It was possible, however, to continue operation with occasional shutdowns until June, 1931, after which a further change was made in tube materials with the view of obtaining better life from the reheaters.

While the problem of increasing the reheat temperature would appear to involve nothing more than an increase in surface, this very solution became particularly difficult due to lack of space and excessive temperature resulting from the scrubbing action of the flame where space could be found available. Fig. 1 shows the original reheater arrangement in each side wall of each boiler. The reheater was designed for a rise of 250 deg., whereas only 125 deg. was obtained. The lack of temperature rise was due, at least in part, to the fact that the path of flame travel in the furnace exposed only a portion of the reheater surface to radiant heat. When changes were made in the firing conditions to eliminate this trouble, large quantities of slag accumulated on the reheater and water-wall tubes which offset any gain made. Various arrangements of slag blowers were tried without effective results.

The next effort to increase reheat temperature was made by removing every other wall tube, thus reducing the shielding effect on the reheater tubes. While this change had some effect, it was far from adequate to meet the needs. Additional reheater elements were next attached to the furnace side of the water-wall tubes as shown in Fig. 2. These gave practically the desired temperature, but the life of the tubes in certain locations of the side walls proved to be only a few days. Thermocouples embedded in the tube walls showed temperatures on the hot, or outlet, leg as high as 1,200 deg. These temperatures were taken at point *A*, Fig. 2, so that tube-metal temperatures considerably in excess of this existed within the furnace. The additional elements were therefore removed from these hotter parts of the walls, and only those left in were subjected to less severe conditions. The final result was a temperature rise but little better than that originally obtained.

It was noted, however, when the change shown in Fig. 2 was made that only the outlet tube, or hot leg of the element, attached to the furnace side of the water-wall tube failed or showed any distress due to excessive heat. It was therefore believed that elements could be made with inlet legs on the outside or furnace side of the water-wall tubes and outlet legs behind and shielded by the water-wall tubes. Accordingly, this arrangement was made up and installed as shown in Fig. 3. All of the old elements behind the water-wall tubes were left in place except those that had to be removed to make room for the hot leg of the new elements. This change was completed in July 1930, and appeared to be the permanent solution to the problem. The proper reheat was being obtained. However, as previously mentioned, occasional leaks began to develop in the furnace side reheater tubes near the top after seven months of practically continuous service. Laboratory examinations of these tube failures showed that metal temperatures of around 1,100 deg. had obtained near the points of failure. Sections of the tubes removed from points near the failure showed no alarming signs of overheat externally, but showed a heavy internal coating of magnetic oxide of iron.

Up to this time all reheater tubes had been manufactured from low-carbon steel meeting A.S.T.M. specifications No. A83-27. Inasmuch as there appeared to be, on this particular job, no other location for reheaters more suitable, the only solution seemed to be to find a material suitable for the tubes in the existing location. An investigation of Enduro, or KA-2, showed it unsuitable at high temperature for use where fuels contained sulphur, and also that KA-2S would be unsuitable where the sulphur content of the fuel exceeded 2.5 per cent. Inasmuch as most of the fuel used at the station contains at least 3 per cent sulphur, these two alloys, representing the best of their class, were ruled out. Experience at the plant on booster superheaters shows the chrome-vanadium alloys to be little or no better than low-carbon steel.

A year's use of the experimental high-temperature superheater at Detroit had shown calorized low-carbon steel tubes quite effective in resisting high temperatures both outside and inside the tube. While the year's use seemed to show some thinning of the outer calorized coating, it was believed to be in such condition that a very reasonable life could be expected from the calorized units. As these metals just mentioned seemed to cover the better known high-temperature-resisting metals for tubes, it was decided to try the calorizing. Accordingly, two complete sets of elements were made up to the same form as those shown in Fig. 3, except that the leg attached on the furnace side of the water-wall tube was calorized both inside and out. The two reheaters so equipped were put in serv-

GENERAL OPERATING CONDITIONS AT NORTHEAST STATION

Normal operating drum pressure, lb. gage	1,350
Maximum evaporation per boiler, lb. per hr	225,000
Normal evaporation per boiler, lb. per hr	185,000
Pressure at turbine throttle, lb. gage	1,250
Temperature at turbine throttle, deg. F	725
Back pressure at turbine exhaust, lb. gage	315
Superheat in exhaust at full load, deg. F	22
Pressure of steam out of reheater, lb. gage	290
Temperature of steam out of reheater, deg. F	700

*Excerpts from paper to be given at the Kansas City meeting of the A.S.M.E., Sept. 7 to 9.

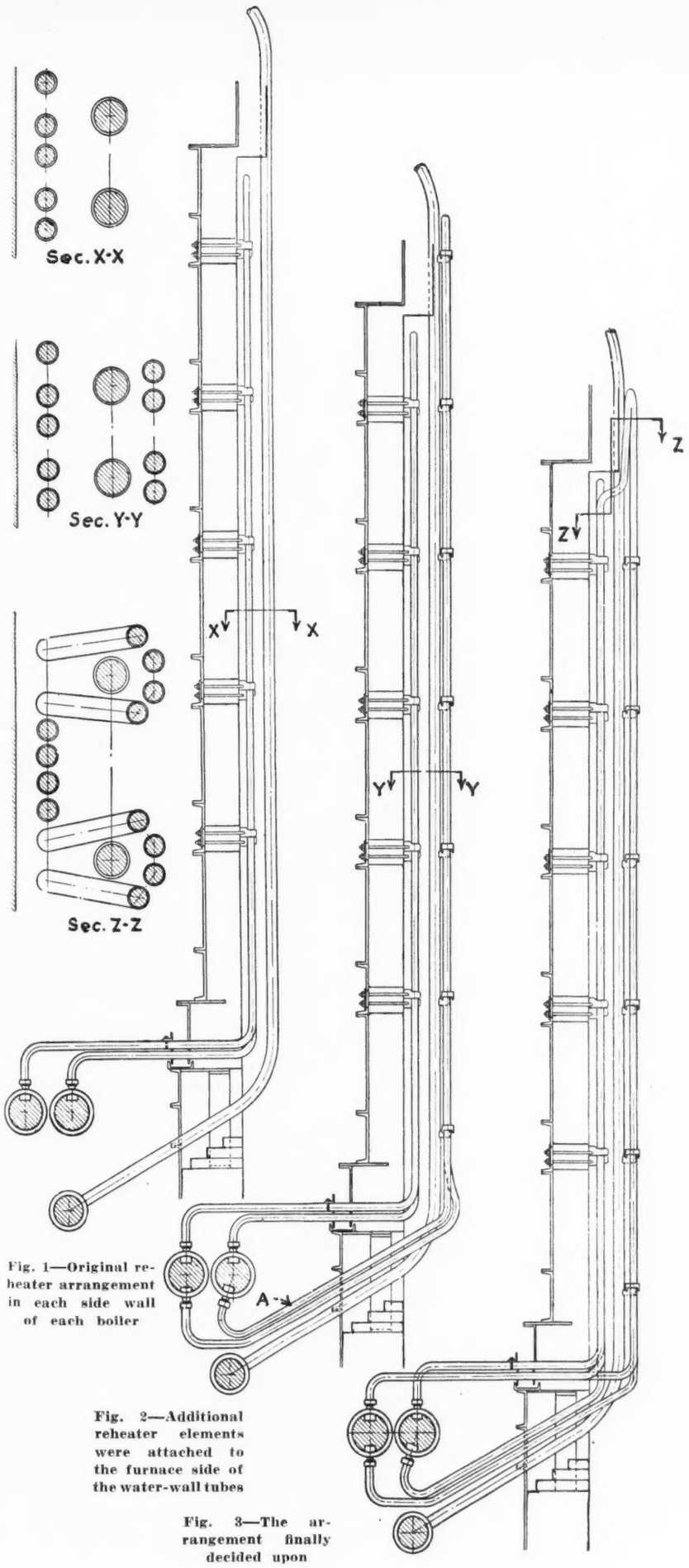


Fig. 1—Original reheater arrangement in each side wall of each boiler

Fig. 2—Additional reheater elements were attached to the furnace side of the water-wall tubes

Fig. 3—The arrangement finally decided upon

ice the early part of August of this year, and will, it is confidently believed, prove the final solution to the reheater trouble.

The preceding outlines only the major changes made to the reheaters. Many minor changes were made on the first and second installations, such as the use of orifices for changing steam distribution, alteration of burners, and, finally, the addition of auxiliary burners near the bottom of the side walls. All of these changes, particularly the latter, have contributed their share in the solution of the problem.

Turbine Experience

The dependability of service availability of the turbine has been high. Some trouble was experienced during the first three months with balance of the generator rotor and turbine alignment. However, after correcting these troubles its service availability was nearly 100 per cent until its first inspection after thirteen months' use. With the exception of a few minor items the turbine was found to be in perfect condition. During the second year the turbine continued to give almost equally good service from the mechanical standpoint. However, trouble experienced during the first year from scale deposit on the blades continued throughout this second year, necessitating frequent washing. This trouble evidenced itself by loss of load and a gradual building up of the pressure on the reaction blading.

No scale deposit has ever been formed in either the primary superheater or reheater tubes. It seems to form only on the last three rows of blades of the high-pressure turbine and again in the lower stages of the low-pressure turbines operating off the exhaust of the high-pressure unit. The analysis of the scale from both locations is essentially the same and shows it to consist largely of silicates of iron and aluminum which are quite insoluble in water.

The boilers, water walls, superheater and economizer have developed no defects and give no indications that maintenance will be any higher than on the 300-lb. pressure boiler units in the plant. There have been three boiler tube failures—the first due to a defective tube, the second damaged to the first failure and the third to almost complete stoppage of circulation in the tube by mud resulting from a series condenser leak. The tubes are free from scale and have never been turbined. Careful and correct control of the oxygen content of the feed water has successfully prevented any pitting or corrosion either in the boiler, water walls or economizer.

The results obtained from the high pressure equipment have been such, however, that there is no question regarding its justification. The cost of the installation was about $1,650,000, and based on the actual operating economy of the equipment a load factor of 36.5 per cent would result in a saving which would justify the increase in investment over 300-lb. equipment.

NEWS of the FIELD

Thirty-Five Organizations to Take Part in Southwest Power Conference, Sept. 7-11

A. S. M. E. technical sessions, 49th annual convention of the N. A. P. E. and power exposition among the many features

ONE of the most comprehensive power meetings ever planned for any section of the country, the Southwest Power Conference will be held in Kansas City, Mo., from Sept. 7 to 11 inclusive. Eighteen engineering societies, utility organizations and trade associations will participate in the conference, along with the mechanical engineering departments of seventeen universities and colleges in the Southwest. Rounding out the conference with a generous display of power machinery, equipment and accessories, the Southwest Power and Mechanical Exposition will be held during the course of the meeting in the Kansas City Convention Hall.

Technical sessions covering many important phases of the power field are scheduled on the programs of participating organizations, as well as general sessions in which all attending will take part. General and technical sessions will be held in the auditorium of the Kansas City Power & Light Company's new building at 14th and Baltimore Ave. A full quota of social events and sightseeing trips are included on the program, along with many special entertainment features.

The conference will open on Monday morning, Sept. 7, with an address of welcome by Joseph F. Porter, president of the Kansas City Power & Light Company and honorary chairman of the conference. Responses will then be heard from representatives of each of the participating organizations, which include the American Society of Mechanical Engineers, National Association of Power Engineers, American Institute of Electrical Engineers, American Society of Civil Engineers, American Society of Heating and Ventilating Engineers, American Chemical Society, National Electric Light Association, National Safety Council, state utility associations, universities and colleges, the coal, gas and oil industries.

Sessions of the A.S.M.E., whose headquarters for the conference will be at the Kansas City Athletic Club, will cover power plants, fuels, oil and gas power, petroleum and aeronautics. The papers to be presented include: "1,400-Lb. Pressure Boiler and Turbine Operation at Northeast Station," J. A. Keeth; "Diphenyl Oxide," John J. Grebe; "Flour Milling and Power Requirements," Grove C. Meyer; "Coal as a Basic Fuel," H. Kreisinger; "Improvements in Mining and Preparing Strip Coal in the Southwest," L. Russell Kelce; "A Speed Characteristic for Oil Engines," V. L. Maleev; "Diesel Engines as Peak Load Units," S. A. Hadley; "Developments in Internal-Combustion Engines for Use in the Oil Industry," H. F. Sheperd.

The N.A.P.E., with headquarters at the Baltimore Hotel, will hold the six business sessions of its 49th annual meeting in the Missouri Theater. Features of these sessions include addresses by national officers and prominent engineers, committee reports and discussions of association affairs. Lectures will be given by Dr. R. H. Miller and Albert L. Maillard, consulting engineer of Kansas City and general chairman of conference. Many interesting inspection trips are planned, along with the customary social functions.

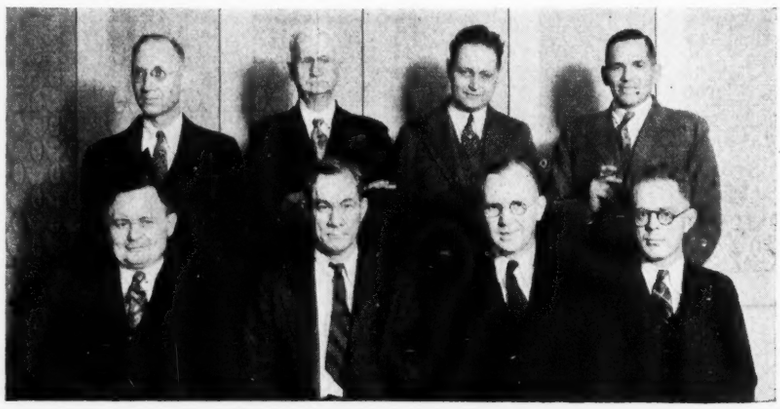
During the conference meetings of the power, engineering and commercial sections of the N.E.L.A. will be held. Problems of the Sub-Committee on Oil Pumping, Production and Refining will be discussed at the Power Section meeting, with Chairman W. H. Stueve presiding.

R. E. McDonnell, of Burns & McDonnell Engineering Company, will present a paper on "Requirements for Successful Management of Municipal Plants" at the meeting of the State Association of Municipal Utilities of Missouri, Kansas, Nebraska and Iowa. Others who will speak on the same topic are L. C. Angevine, superintendent of the water and light plant at McPherson, Kan., and H. L. Lingo, superintendent of the plant at Horton, Kan. A general discussion of matters pertaining to state associations will follow.

North Platte (Neb.) Steam Station Nears Completion

CONSTRUCTION is progressing rapidly on the new generating station of the Northwestern Public Service Company being built on the banks of the Platte River at North Platte, Neb. The structure is largely completed and most of the major equipment has been installed. It is expectd that the plant will be in operation by November.

Initial equipment in this station will consist of a 3,000-kw. turbine-generator and two 6,000-sq.ft. boilers operating at 400 lb. pressure. The plant is unique in design in that the furnace is suitable for burning natural gas, fuel oil, or pulverized coal. Another unusual feature of the plant is that two large deep



N.A.P.E. Convention Committee: Standing—J. M. Razer, president of the local association; William Bartrim, chairman of the reception committee; E. L. Hendrickson, chairman of the exhibit committee; A. F. Thompson, general chairman. Seated—F. G. Ehlers, chairman of the finance committee; Frank R. Hunter, general secretary; Charles Dillon, chairman of housing; Weldon Mooney, chairman of publicity

wells are to furnish the circulating water for all of the station's requirements which will be approximately 3,000,000 gal. per day. These wells have been drilled and tested by pumps delivering 1,500 gal. of water per minute; during this test the ground water was lowered only nine feet.

San Bernardino Not to Buy Hoover Dam Power

CITIZENS of San Bernardino, Calif., have voted to withdraw from membership in the Metropolitan Water District of Southern California and also rejected a proposal that the city contract with the federal government to purchase electric power from the Hoover Dam power plants. The vote on the proposition that the city withdraw from the water district was, yes, 3,052; no, 972. On the power purchase proposal the vote was, yes, 1,048; no, 2,896.

The election was called by the city council after hearing assertions that San Bernardino would not receive adequate benefits in proportion to the cost of participation in plans of the Metropolitan Water District to bring water to a number of Southern California cities from the Colorado River. San Bernardino was among the first cities to join the water district and also was included in a group of Southern California cities, other than Los Angeles, originally designated by the federal government as Hoover Dam power allottees. San Bernardino was to receive a share of the six per cent of the power allocated to this group of cities.

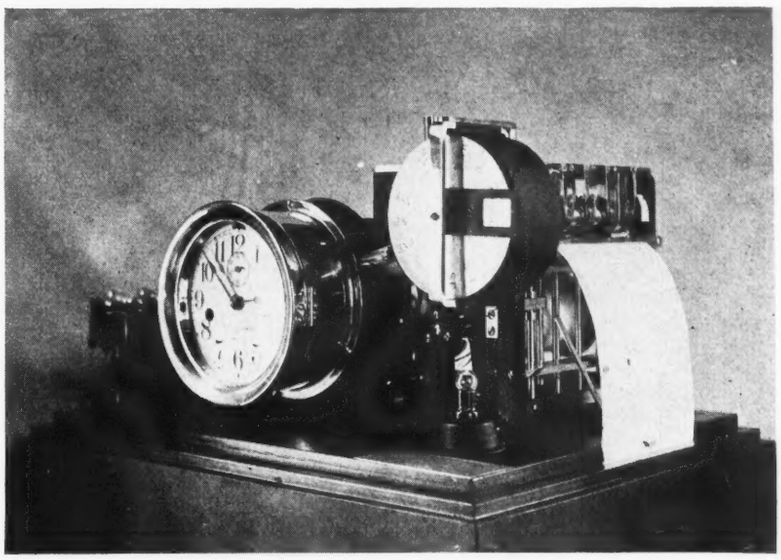
Commission Calls for Bids on Muscle Shoals

ALTHOUGH the Muscle Shoals Commission has invited many chemical firms and manufacturing industries using large amounts of power to submit bids for the leasing and operation of the Muscle Shoals project, members of the commission are inclined to doubt that an acceptable offer will be made at this time. The bids will be opened in Washington on Sept. 1. It has been stated by Col. J. I. McMullen, a member of the commission, that the main purpose of requesting bids at this time is to aid in the development of a plan for disposing of the project. If definite information can be obtained as to the amount that can be secured by leasing the project, it is hoped that Congress will authorize the commission to enter into a suitable contract.

The Muscle Shoals Commission was appointed by the President, the legislature of Tennessee, and the Governor of Alabama. Whatever proposals the commission may obtain for leasing the project must be submitted to Congress. Since the production of fertilizer is regarded as being of paramount importance, partiality will be shown to the bids that seem the most promising from the standpoint of agriculture even though they may be lower than other bids.

Members of the commission believe that of all of the firms and organizations that are being asked to bid, the American Farm Bureau Federation is apt to submit the most acceptable proposal. This is because the Farm Bureau Federation is particularly interested in the production of fertilizers at low costs. It is pointed out in this connection that the southern tier estates in the territory adjacent to Muscle Shoals need much more fertilizer for their soil than the other sections of the country.

NEW WIND RECORDER FOR SMOKE ABATEMENT



An automatic wind recording instrument has been added to the smoke abatement laboratory at Stevens Institute of Technology to aid Col. Elliott H. Whitlock, research professor of mechanical engineering, in studying the rate of air pollution in the New York City area. Designed by Samuel G. Frantz, consulting engineer, the new device prints on a strip of paper the direction and velocity of the wind at regular intervals during day and night. Later it may be equipped to record the actinic value of the light, so that the amount and direction of air pollution may be readily determined

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Hershey Company's New Plant Goes in Service

THE NEW STEAM PLANT of the Hershey Chocolate Company, located at Hershey, Pa., has just been placed in operation, with an installation of three boilers fired by pulverized coal. Each of the boilers is designed to generate 150,000 lb. of steam per hour at a pressure of 450 lb., when operating at maximum capacity. Two Peabody pulverized-coal burners are firing each of the boilers, and are designed to meet the maximum requirements of 7,000 lb. of coal per burner per hour. The plant is fully automatic, requiring no manual control for the regulation of either air or fuel.

Beauharnois Project to Undergo Reorganization

THE CANADIAN BANKS have practically agreed to carry on the financing of the Beauharnois power project until October, by which time it is expected reorganization plans will have been effected.

In the meantime, it is evident that the company will be obliged to start all over again in the process of securing the consent of the Dominion Government and otherwise complying with the legislation passed at the end of the Parliamentary session following the inquiry. Presumably, the necessary proceedings will be initiated without delay if the works are to be uninterrupted. The company, it is stated, must prepare and present plans for the works with as great detail as possible, submit them to the government and ask for their approval. It will then be for the Cabinet to discuss and decide on the terms and conditions under which sanction will be given. The old order-in-council had 28 conditions attached. These may be reaffirmed or varied or supplemented.

It is indicated that the intention of the government is to exact a new agreement covering the whole matter. The company, it is further stated, will be expected for the purpose of navigation to hand over to the Dominion Government in fee simple the lands and appurtenances required for such purposes. Under the old order-in-council, the government at any time was entitled to the free use and utilization of the canal for navigation, but ownership was vested in

the company. Now, in respect to navigation, the government plans to be the owner and the company the user. This will overcome what in the recent debate in Parliament was referred to as the anomaly of national waterway on private property.

When the new act of Parliament is brought into force, in sequence to the new agreement, the company will be confirmed in its authorized diversion of 53,000 sec.ft. of the flow of the river. The additional flow, which the recent investigation disclosed the canal is being built to accommodate and utilize, will require a further agreement with the government on whatever terms are decided.

Seattle to Spend $4,352,972 On Power Additions in 1932

DURING 1932 the City Light Department of Seattle, Wash., will spend $4,352,972 on new construction, according to the preliminary budget of the department now under study by the City Council. The light department is self-supporting, and the money used for construction will not come from the city's tax levy, so this item may be allowed to stand in the budget. As submitted, the entire light department budget for 1932 will total $10,994,213 as compared with $8,905,026 for the year 1931.

A.S.R.E. Announces New Annual Data Book

A NEW ANNUAL will appear in the spring of 1932 under the title, "The Refrigerating Data Book and Catalog." According to the publishers, The American Society of Refrigerating Engineers, this will combine an encyclopedia of modern refrigeration by 40 experts with a condensed catalog service of refrigerating apparatus. The plan is to unify the statistical and technical literature of the field of refrigeration, now buried in scattered periodicals and other inaccessible sources, and to bring together the scattered trade literature aimed at this miscellaneous market.

The text section of about 400 pages will give attention to the basic principles of refrigeration, machinery, equipment—a collection of authoritative treatises on all the applications of refrigeration, especially the newer ones, in commercial and industrial uses. This includes "dry ice," food freezing, air conditioning, building equipment, food processing, ice cream, ice, cold storage, mobile refrigeration, trucks, show cases, liquid cooling, chemical plant applications and others.

The condensed catalog section which will occupy the second half of the book will be arranged by companies, each advertiser having all his pages in one spot, with appropriate indexing of his products.

COMING CONVENTIONS

American Society of Mechanical Engineers. Regional meeting in Kansas City, Mo., Sept. 7-9. Annual meeting in New York City, Nov. 30-Dec. 4. Secretary, Calvin W. Rice, 33 West 39th St., New York City.

American Association of Engineers. Seventeenth annual convention at Huntington, W. Va., Sept., 28-30. Secretary, M. E. McIver, Willoughby Tower, Chicago, Ill.

American Institute of Electrical Engineers. District meeting at Lake Tahoe, Calif., Aug. 25-28. District meeting at Kansas City, Mo., Oct. 22-24. Secretary, F. L. Hutchinson, 33 West 39th St., New York.

American Welding Society. Fall meeting at the Copley-Plaza Hotel, Boston, Mass., Sept. 21-25. Secretary, M. M. Kelly, 33 West 39th St., New York City.

Association of Edison Illuminating Companies. Forty-seventh annual meeting at The Greenbrier, White Sulphur Springs, W. Va., Sept. 21-25. Secretary, Preston S. Millar, 80th St. and East End Ave., New York City.

International Railway Fuel Association. Annual convention at the Hotel Sherman, Chicago, Ill., Sept. 15-16. Secretary, C. T. Winkless, Room 700, La Salle Street Station, Chicago, Ill.

National Association of Power Engineers. Annual convention and mechanical exposition in the Convention Hall, Kansas City, Mo., Sept. 7-11. Secretary, Fred W. Raven, 417 South Dearborn St., Chicago.

New England Water Works Association. Fiftieth annual convention at the Hotel Statler, Boston, Mass., Sept. 29-Oct. 2. Secretary, Frank J. Gifford, 715 Tremont Temple, Boston, Mass.

Southwest Power Conference and Show will be held in Convention Hall, Kansas City, Mo., Sept. 7-11. Secretary, George F. Klein, Chamber of Commerce, Kansas City, Mo.

Third International Conference on Bituminous Coal. At Carnegie Institute of Technology, Pittsburgh, Pa., Nov. 16-21. Chairman, Thomas S. Baker, president of Carnegie Institute of Technology.

Empire State Association To Meet on Sept. 10-11

THE Empire State Gas & Electric Association will hold its 26th annual convention on Sept. 10 and 11 at The Sagamore, Bolton Landing, Lake George, N. Y. Topics of interest to public utilities will be discussed at the business sessions each morning, with entertainment features scheduled for the afternoon and evening.

Among the addresses that will be given at the sessions are: "Natural Gas in New York State," by E. B. Swanson; "Federal Encroachment on State Regulation," by Carl D. Jackson; "The Utility Tax Burden," by Mark Graves; "The East Comes Back," by Harry Reid; "The Conference Leader Method of Employee Training," A. L. Mann.

Personals

J. R. BAKER, operating engineer of the Pennsylvania Water & Power Company, has been appointed chairman of the Committee on Power Generation of the American Institute of Electrical Engineers. Among those appointed chairmen of other technical committees of the A.I.E.E. are: General Power Applications, C. W. DRAKE, general engineer of the Westinghouse company; Power Transmission and Distribution, P. H. CHASE, chief engineer of the Philadelphia Electric Company; Electrical Machinery, P. L. ALGER, engineering general, General Electric Company; Electric Welding, P. P. ALEXANDER, research engineer, General Electric Company; Research, L. W. CHUBB director of the Westinghouse Research Laboratories; Standards, A. M. MACCUTCHEON, engineering vice-president of the Reliance Electric & Engineering Company.

WILLIAM A. CALDWELL, of Jackson, Tenn., has resigned from the Muscle Shoals Commission. In submitting his resignation to Governor Henry Horton of Tennessee, Mr. Caldwell objected to the lack of consideration given to the possibility of using the Muscle Shoals plant for quantity production of electric power for small consumers. He declared he was unwilling to subscribe to a "preconceived plan to devote the property primarily to the production of fertilizer," which he claimed the majority of the commission were following.

L. R. KING has been named president and general manager of the Iowa-Nebraska Light & Power Company and the Maryville (Mo.) Electric Light & Power Company, subsidiaries of the United Light & Power Corporation. Mr. King has been assistant general manager of the latter company as well as of the United Light & Power Engineering & Construction Company, with headquarters in Davenport, Iowa.

WILLIAM S. RICHHART, operating engineer of the Insull properties in the northern part of Indiana, has assumed charge of the distribution service for all Insull properties in the Midland United Company.

A. A. LOW has been elected executive vice-president of the Utica Gas & Electric Company, a subsidiary of the Niagara Hudson Power Corporation. Mr. Low has been for some time identified with various public utility interests in central New York and is president of the Old Forge Electric Company.

ROBERT C. COFFY has been appointed manager of the eastern division of the Oklahoma Gas & Electric Company to succeed W. H. CRUTCHER, who died recently. W. S. VAN SICKEL has been named to succeed Mr. Coffy as vice-president and general manager of the Mississippi Valley Power Company and president of the Fort Smith Traction Company.

Business Notes

WORTHINGTON PUMP & MACHINERY CORPORATION, Harrison, N. J., announces the acquisition of the manufacturing and marketing facilities of METALWELD, INC,, Philadelphia, Pa., makers of a complete line of portable compressor units. The new line will be manufactured at Harrison, it is stated, and the engineering, manufacturing and sales personnel of the Metalweld organization will be relocated there.

LEAVITT MACHINE COMPANY, Orange, Mass., announces the purchase of the separator business of the SWENDEMAN CORPORATION, Boston, Mass. Through this combination Mr. Swendeman, who is an authority on problems relating to the separation of moisture from compressed-air lines, becomes associated with the Leavitt concern.

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, East Pittsburgh, Pa., announces that William F. James, formerly manager of the middle Atlantic district, has been appointed assistant to the commercial vice-president of the company's Atlantic division. It is also announced that E. W. Loomis, formerly manager of the northeastern industrial division, has been named to succeed Mr. James as middle Atlantic district manager, with headquarters in Philadelphia.

RELIANCE GAUGE COLUMN COMPANY, Cleveland, Ohio, announces that it has purchased the safety water column, water gage, gage cock and gage-glass illuminator business of the ROBERTS STEAM SPECIALTY COMPANY and the CLEVELAND FLUE CLEANER MANUFACTURING COMPANY, both of Cleveland. These products are being improved and consolidated with the Reliance line, it is stated, and replacement parts may now be obtained from the Reliance company.

KING REFRACTORIES COMPANY, Cleveland, Ohio, announces the appointment of W. Bryce McQuiston, 305 Renshaw Building, Pittsburgh, Pa., as its sales representative in that territory. Mr. McQuiston has been associated with the KIER FIRE BRICK COMPANY for a number of years.

PEABODY ENGINEERING CORPORATION, New York City, announces that the H. W. Kaiser Company, 1836 Euclid Ave., Cleveland, Ohio, is now acting as its representative in the northern Ohio section. Mr. Kaiser, it is stated, has severed connections with the Hughes Limbach Company, former representative of Peabody in that district, and has gone in business for himself.

C. A. DUNHAM COMPANY, Chicago, Ill., announces the appointment of Macy S. Good as division manager of sales, effective Sept. 1. For the past ten years Mr. Good has been manager of the company's Chicago sales office.

How's Business?

OUR INDEX, which has been falling slowly since March, has run into new low ground during August, and monthly figures indicate that the level of last December, which everyone hoped was the bottom, has been slightly outdone by the midsummer months, says *The Business Week* of Aug. 26. Steel activity is probably at its ebb, but as yet gives no hint of prospective Fall demand. Building has slumped badly in August, and the trends of electric power production, merchandise carloadings, check payments and commercial loans since July show the severe effects of summer stagnation in a depression year.

Production of electricity by public utilities for the week ended Aug. 15 was 1,629,011,000 kw.-hr., according to N.E.L.A. figures. This shows a decrease of about 1 per cent from the previous week and is 2.9 per cent below the corresponding period of 1930.

Trade Catalogs

STEAM ENGINES—Details of the construction and operation of Wachs Type R fully enclosed self-oiling vertical steam engines are given in illustrated Bulletin R-31, recently issued by the E. H. Wachs Company, 1535 Dayton St., Chicago, Ill. These engines are built in a range of sizes from 2 to 65 hp., for speeds up to 1,150 r.p.m. and pressures up to 250 lb. with or without superheat.

OIL BURNERS—Bulletin No. 106, just issued by the Peabody Engineering Corporation, 40 East 41st St., New York City, describes the construction, operation and applications of Peabody oil burners. A discussion of the Peabody wide-range system of atomization is included, together with a description of the insulated panel burner front for use with preheated air, and several illustrations of actual installations.

FITTINGS—The Carrick Engineering Company, 431 South Dearborn St., Chicago, Ill., has issued a new bulletin illustrating the Carrick stiff-arm fittings used to rigidly connect the regulating units of the combustion control system and the devices which are to be controlled such as dampers, motor controllers, regulating valves and shafts.

CONVEYORS—A complete catalog of conveying and special elevating machinery has just been published by the Fairfield Engineering Company, Marion, Ohio. Coal handling and power plant equipment is fully described, together with blueprints and illustrations of actual installations.

INDICATORS—The design and operation of Maihak indicators for gas compressors and gas engines are discussed in two bulletins recently issued by the Bacharach Industrial Instrument Company, 7000-6 Bennett St., Pittsburgh, Pa. Bulletin 3264 is entitled "Safeguarding the Gas Compressor," and Bulletin 3265, "Gas Engine Efficiency."

BEARINGS—"Steel-Backed Babbitt-Lined Bearings" is the title of a new illustrated bulletin issued by the Wagner Electric Corporation, 6400 Plymouth Ave., St. Louis, Mo., which discusses the problem of bearing seizure in electric motors and the advantages of babbitt bearings.

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Fuel Prices

FUEL OIL

Boston—Aug. 17, tank-car lots, f.o.b. 12@14 deg. Baumé, 2.9c. per gal.; 28@32 deg., 4.58c. per gal.

New York—Aug. 20, f.o.b. Bayonne, N. J., 28@34 deg. Baumé, industrial use, tank-car lots, 3.75c. per gal.; f.o.b Bayway, 36@40 deg., furnace, tank-car lots, 4.75c. per gal.

Philadelphia—Aug. 13, No. 3, industrial gas oil, $1.83 per bbl.; No. 4, light industrial fuel oil, $1.31 per bbl.; No. 5, medium industrial fuel oil, $1.20 per bbl.; No. 6, heavy (Bunker C), $1.05 per bbl.

Pittsburgh—Aug. 12, f.o.b. local refinery, fuel oil, 30@34 deg., 2.5c. per gal.; 36@40 deg., 2.75c. per gal.

Cincinnati — Aug. 18, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 4.5c. per gal.; 26@30 deg., 4.75c. per gal.; 30@32 deg., 5c. per gal.

Chicago—Aug. 10, tank-car lots, f.o.b. Oklahoma; freight to Chicago, 90c. per bbl. or 42 gal.; 18@22 deg., 22.5c. per bbl.; 22@24 deg., 25c. per bbl.; 24@26 deg., 27.5c. per bbl.; 26@28 deg., 32.5 per bbl.; 28@30 deg., 37.5 per bbl.

St. Louis — Aug. 10, tank-car lots, f.o.b. St. Louis, 24@26 deg., 99.5c. per bbl., or 42 gal.; 26@28 deg., $1.045 per bbl.; 28@30 deg., $1.12 per bbl.; 30@32 deg., $1.17 per bbl.; 32@36 deg., gas oil, 2.401c. per gal.; 38@40 deg., distillate, 2.901c. per gal.

Dallas—Aug. 15, f.o.b. local refinery 24@26 deg., 70c. per bbl. or 42 gallons.

COAL

Bituminous (Net Tons)	At Mine, for Shipment to	Price per Ton
Pool 9, super low-vol.	New York	$1.65 @ $1.80
Pool 10, h. gr. low-vol.	New York	1.50 @ 1.65
Pool 11, low-vol.	New York	1.40 @ 1.50
Smokeless, mine-run	Chicago	1.50 @ 1.75
Smokeless, slack	Chicago	.50 @ 1.10
Harlan, Ky., slack	Chicago	.85 @ 1.10
Franklin, Ill., mine-run	Chicago	2.15
Franklin, Ill., screen	Chicago	1.20 @ 1.60
Ind. 5th Vein, m.-r.	Chicago	1.20 @ 1.75
Standard Ill., mine-run	St. Louis	1.25 @ 1.40
W. Ky., mine-run	Louisville	.85 @ 1.25
W. Ky., slack	Louisville	.50 @ .55
Pittsburgh, mine-run	Pittsburgh	1.25 @ 1.35
Smokeless, mine-run	Cincinnati	1.60 @ 1.75
Smokeless, slack	Cincinnati	.50 @ 1.00
Kanawha, mine-run	Cincinnati	1.00 @ 1.25
Kanawha, nut-slack	Cincinnati	.50 @ .75
Anthracite (Net Tons)	**At Mine, for Shipment to**	**Price per Ton**
Buckwheat	New York	$3.25
Barley	New York	.90 @ 1.40

New Plant Construction

COMPILED BY THE MCGRAW-HILL BUSINESS NEWS DEPARTMENT, WHICH IS PREPARED TO FURNISH A MORE COMPLETE DAILY SERVICE TO THOSE WHO WISH IT

Conn., Hartford—Hartford Post Office, J. A. Wetmore, Treasury Bldg., Washington, D. C., will receive bids until Sept. 10 for the construction of a post office at Church, Allen and Huntley Sts. Estimated cost $1,200,000. Malmfeldt, Adams & Prentice, 15 Lewis St., are architects.

Delaware and District of Columbia—Pennsylvania R.R., Broad St. Station, Philadelphia, Pa., plans the construction of an underground conduit and signal system for electrification of railroad from Wilmington, Del., to Washington, D. C. Estimated cost $7,000,000. T. J. Skillman, Philadelphia, is chief engineer. Work will be done by day labor.

Ga., Augusta—Augusta Canal Co., plans the construction of a new power plant. Estimated cost $1,000,000. Burns & McDonnell Engineering Co., 400 Interstate Bldg., Kansas City, Mo., is engineer.

Ill., Chicago—Commonwealth Edison Co., 72 West Adams St., awarded contract for the construction of a power plant to G. A. Fuller Co., 32 West Randolph St. Estimated cost to exceed $150,000.

Ill., Calumet City—Sanitary District, awarded contract for the construction of a complete pumping station in connection with sewage treatment plant at 126th St. and Cottage Grove Ave. to John Griffiths & Son Co., 228 North La Salle St., Chicago, Ill.

Ind., Crown Point—City plans the construction of an electric light plant including Diesel engine. Burns & McDonnell Engineering Co., 400 Interstate Bldg., Kansas City, Mo., is engineer.

Ia., LeMars—City plans an election on Sept. 3 for proposed power plant and distribution, etc. Estimated cost $425,000.

Ky., Harlan—City will not construct new power plant. Burns & McDonnell Engineering Co., 400 Interstate Bldg., Kansas City, Mo., Engr. Project abandoned.

La., Ruston—City, C. C. Coyne, Mayor voted $180,000 bonds for the construction of a gas plant.

Mass., Boston—House of Liederman Inc., 169 Norfolk Ave., Roxbury, awarded contract for the construction of a boiler plant to H. E. Cline, 43 Tremont St. Estimated cost $40,000.

Mass., Holyoke—City, J. O'Brien, had plans prepared for waterworks improvements, including 20 x 25 ft. pump house, etc. Private plans.

Mass., Lowell—Lowell Electric Light Corp., J. A. Hunnewell, Pres., 35 Market St., awarded contract for the construction of a 1 and 2 story service building on Perry St., to New England Power Construction Co., 89 Broad St., Boston. Engrs. Estimated cost $100,000. Engineers receiving bids on sub-contracts.

Mass., Westboro—Commonwealth of Massachusetts, Dept. of Public Welfare, will soon award contract for reconstruction and alterations to boiler house at Lyman School for Boys. Estimated cost $50,000. Densmore, LeClear & Robbins, Park Sq. Bldg., Boston, are architects.

Mich., Wyandotte—City, is having plans prepared for the construction of a power plant including steam operated electric power generating equipment at Van Alstyne Blvd. and Vinewood Ave. Estimated cost $300,000. Forelich & Emery, Second National Bank Bldg., Toledo, O., are engineers.

Minn., Ely—City, A. O. Knutson, Clk., is having plans prepared for a waterworks system to include pump house, three pumps, mains, etc. Estimated cost $200,000. Oliver Iron Mining Co., Wolvin Bldg., Duluth, is engineer.

Minn., Fergus Falls — Ottertail Power Co., awarded contract for a 7,500 kw. turbine generator unit to Westinghouse Electric & Mfg. Co., 150 Broadway, New York, N. Y. Estimated cost to exceed $40,000.

Mo., Waverly—City plans an election Aug. 31 to vote $45,000 bonds for a waterworks system including pumping station and equipment, tank on tower and distribution mains, etc.

Mont., Hot Springs—City, N. Hood, Clk., will receive bids until Aug. 31 for the construction of a waterworks system including deep well, centrifugal pump, etc. Estimated cost $30,000.

N. J., Newark—Bd. of Education, City Hall, will receive bids until Sept. 10 for the construction of a junior and senior high school including steam heating and ventilation systems, boilers, etc. on Chancellor Ave. Estimated cost $1,080,000. Guilbert & Betelle, 20 Branford Pl., are architects.

N. J., Newark—Leo Schloss Inc., Foot of Astor St., awarded contract for the construction of a beef cooler to Lustbader Construction Co., 145 East 45th St., New York. Estimated cost $40,000.

N. J., Orange—Bd. of Commissioners, City Hall, will receive bids until Sept. 1 for the construction of a water pumping station and electric light plant on Chestnut St. Estimated cost $425,000. Runyon & Carey, 31 Fulton St., Newark, are engineers.

N. Y., New York—New York Steam Corp., 280 Madison Ave., plans additional steam pipe lines and plant additions. Estimated cost $2,500,000. Work will be done by day labor.

N. C., Oteen—U. S. Veterans Bureau, c/o L. H. Tripp, Washington, D. C., received lowest bid for the construction of a 76 x 84 ft. boiler house, chimney, pumping equipment, water distribution system, etc. at U. S. Veterans Hospital here from J. M. Geary Co., Asheville, N. C. $134,000.

O., Cincinnati—City postponed construction of water and power plant. Estimated cost $2,700,000. Burns & McDonnell Engineering Co., 400 Interstate Bldg., Kansas City, Mo., is engineer. Project held up temporarily.

O., Columbus—Bd. of Trustees, Ohio State University, C. E. Steeb, Secy., will soon award contract for the construction of a tunnel, 7½ ft. sq. from power plant to new physical education building, also installation of service lines for water, gas, steam and compressed air. Estimated cost $25,000. W. C. McCracken, Ohio State University, is engineer.

O., Franklin—City postponed construction of power plant. Burns & McDonnell Engineering Co., 400 Interstate Bldg., Kansas City, Mo., Engr. Project temporarily abandoned.

O., Hudson — City awarded contract for artesian well, new pumping equipment and filtration and water softening plants in connection with waterworks to W. B. Kester, Akron. $41,000.

O., Piqua—City plans an election in November to vote $810,000 bonds for the construction of a power plant. Burns & McDonnell Engineering Co., 400 Interstate Bldg., Kansas City, Mo., is engineer.

Okla., Pryor—City is having preliminary plans prepared for waterworks system including purification plant, water main extensions, etc., also municipal power plant. Estimated cost $100,000. V. V. Long & Co., 1300 Colcord Bldg., Oklahoma City, are engineers.

S. D., Webster—Northwestern Public Service Co., plans the construction of a power plant, 1,120 hp. capacity to include Diesel engines. Private plans.

Tex., Columbus—Central Power & Light Co., Alamo Bank Bldg., San Antonio, plans the construction of a large hydro-electric development on Colorado River near here. Estimated cost $5,000,000. Owners advise that this contemplated work must wait until completion of present power plant now under construction on the upper Colorado River.

Tex., Fort Sam Houston—A. S. Harrison, Constructing Quartermaster, completed sketches for proposed five year building program to include thirteen field officers quarters, officers quarters, new station hospital, quartermaster warehouses, new barracks, shops and sheds, etc. Estimated cost approximately $15,000,000.

Tex., Gladewater—J. G. Pundt, 2104 Forest Park Blvd., Fort Worth, has been granted franchise to construct waterworks and sewage systems to include well, pump house, pumps, etc. F. J. Zuben, 802 Fair Bldg., Fort Worth, is engineer.

Tex., Plainview—City plans the construction of an electric light and power plant and complete system. Estimated cost $100,000. Engineer not selected.

Equipment Wanted

Boiler, Stoker, etc.—Huntingburg, Ind.—City Council, D. R. Milton, Clk., will receive bids until Aug. 31 for furnishing and erection of a boiler, stoker and accessories for municipal light and power plant.

Boilers, Stokers, Pump, etc.—Cleveland, O.—City will receive bids until Aug. 28 for two cast iron boilers (5,000 sq.ft.) two stokers, one vacuum pump and one 70 ft. radial stack.

Engine—Ford City, Pa.—City will soon receive bids for a 500 kw. Diesel engine for electric light plant.

Pump and Motor—Calexico, Calif.—City, R. S. Emerson, Clk., will receive bids until Sept. 1 for a 1,000 g.p.m. horizontal pump with motor for waterworks.

Pumps—Montreal, Que.—City Water Board, plans the installation of three additional 30,000,000 gal. pumps for waterworks.

Industrial Projects

Calif., Stockton—Fraser Furnace Co., 445 South San Joaquin St., awarded contract for the construction of a 1 story, 110 x 150 ft. factory on Scotts Ave. to F. Zinck, 2034 North Pacific Ave., Stockton. Estimated cost $60,000 including equipment.

Ill., Chicago—Clearing Industrial District, 38 South Dearborn St., awarded contract for the design and construction of a 2 story factory to include offices, laboratories, etc., at 6901-23 West 65th St. to H. K. Ferguson Co., Hanna Bldg., Cleveland, O. Estimated cost $500,000. Pepsodent Co., 919 North Michigan Ave., Chicago, tooth paste and antiseptic manufacturers, lessee.

Ind., Anderson—Anderson Battery Co., awarded contract for the construction of a factory on Center Ave. to F. Cook, Middletown. Estimated cost $40,000.

Mass., North Wilbraham—Collins Mfg. Co., 56 Suffolk St., Holyoke, manufacturers of writing paper, is receiving bids for the construction of a power house here. Estimated cost $50,000. McClintock & Craig, 458 Bridge St., Springfield, are engineers.

O., Painesville — Ford Motor Co., 3674 Schaefer Road, Dearborn, Mich., has option on a 365 acre site on Grand River Harbor near here for the construction of an assembly plant. Estimated cost $7,000,000.

Tex., Corpus Christi—Aransas Compress Co., awarded contract for the construction of six units to present compress plant to C. F. Runck, Corpus Christi. Estimated cost $100,000.

Tex., Corpus Christi—Southern Alkali Corp., subsidiary of Pittsburgh Plate Glass Co., Grant Bldg., Pittsburgh, Pa. and American Cyanamid Co., 535 5th Ave., New York, plans the construction of a plant for the manufacture of soda ash, caustic soda and other products from raw materials here, also ship channel from Corpus Christi to plant site. Estimated cost $10,000,000. Private plans. Maturity about November or later.

Tex., Harlingen — Pure Distributing Corp., Corpus Christi, subsidiary of Pure Oil Co., 35 East Wacker Dr., Chicago, Ill., plans the construction of a gasoline manufacturing plant, 120,000 gal. capacity, at Hanson and F. Sts., here. Estimated cost $40,000. Private plans. Work will be done by owner's forces.

Tex., San Antonio — American Fertilizer & Chemical Works, c/o T. F. Hawkins, Pres., San Saba, plans the construction of a commercial fertilizer manufacturing plant, 100 tons daily capacity, to include pulverizing manufacturing and mixing building, weighing, shipping and storage building, machinery and equipment, etc., at 401 North Comal St. Estimated cost $75,000. Private plans.